MARCH 1958

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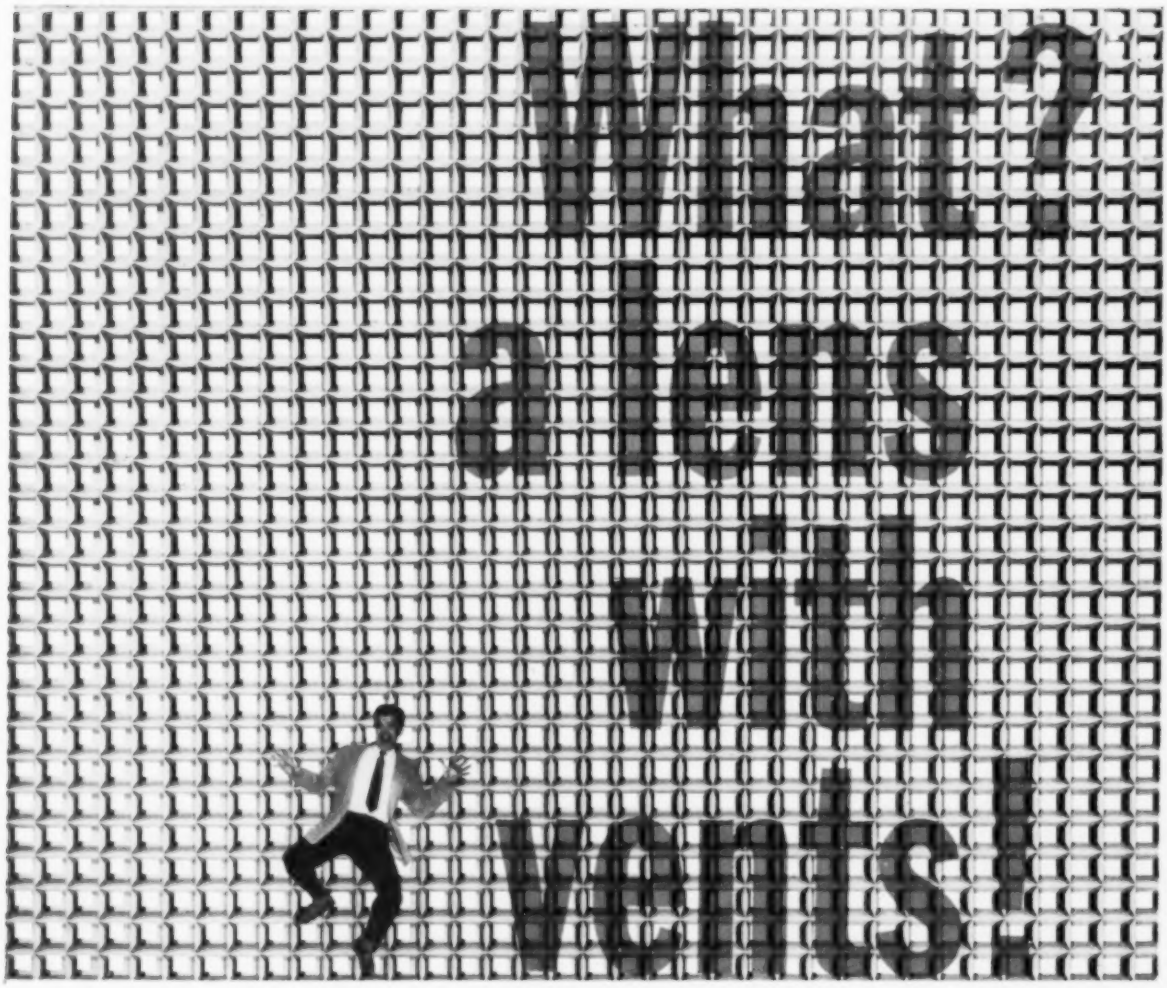
ILLUMINATING ENGINEERING

Journal of the
ILLUMINATING ENGINEERING SOCIETY



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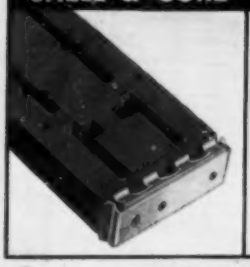				

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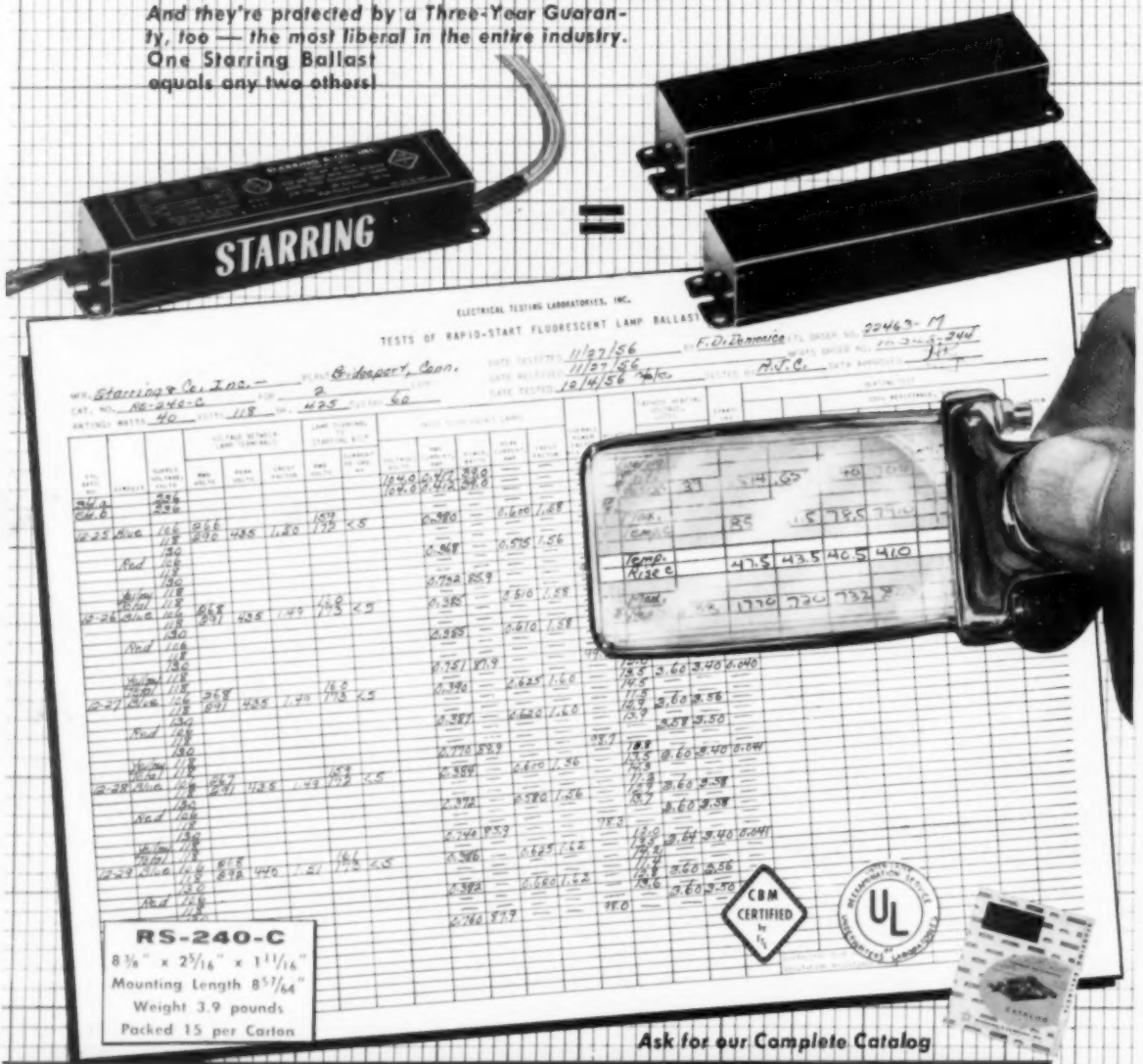

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

March 1958

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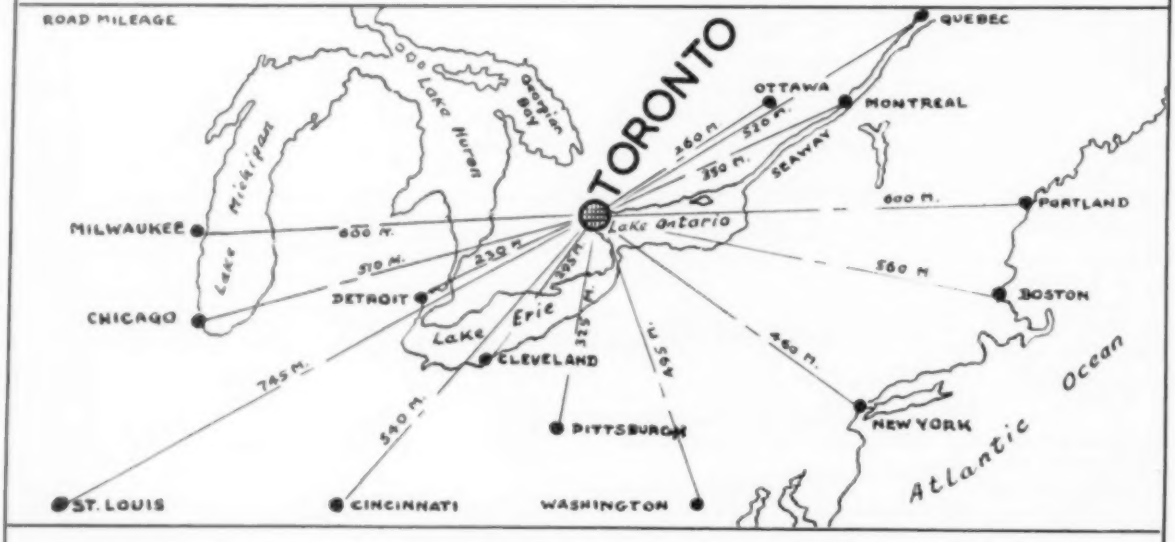

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The diffusing medium (upper photo) is plastic grid louvers. Beauty of this material is that it is easy to work with (it was cut "tailor-made" around the curve of the soffit) . . . it is lightweight . . . translucent . . . and has the functional low brightness look with high light transmission onto the work surfaces. The shielding angles are noteworthy — 45° x 45°.

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Seven Buildings, Seven Ways To Light a Church

Lighting design for churches offers the illuminating engineer and his colleague, the architect, their finest opportunity for using imagination and ingenuity. Architectural styles vary widely, from the graceful and ornamented traditional to the clean lines of contemporary design. Lighting installations are expected not only to provide adequate illumination for the visual task, but also to achieve the far more creative function of adding to the beauty of the building and establishing an atmosphere conducive to meditation and worship.

The seven churches shown here, both modern and traditional, illustrate how illuminating engineering, imaginatively applied, can work together with design in achieving the architectural intent. These installations were all entries in I.E.S. Section/Chapter My Most Interesting Lighting Job contests.

1. St. Cesaire Church

St. Cesaire Church, near Granby, Que., has the traditional beauty of Romanesque architecture repainted and relighted to show to its best advantage. The church is 175 feet long by 60 and 88 feet wide with ceiling height of 60 feet. After repainting the colors were: vault and walls of ivory and light blue (60% RF); floor of beige and light green tile (55% RF) and pews of dark wood (10% RF).

The previous lighting installation of a large suspended luminaire with bare lamps was poor as to both quantity and quality of illumination, and the pastor and board of trustees were persuaded that the recommended relighting was as necessary as the redecoration.

A total of eight recessed round unhoused reflector units was integrated with the architecture by mounting in the center of each vaulted section of the ceiling. Six of these are located over the main isle and ona in each side of the transept. Luminaires over the altar area and at the intersection of aisle and transept each use 1500-watt lamps, the others are 1000-watt. The fixtures are 22½ inches in diameter, 22 inches high, and are equipped with prismatic glass lenses. They are serviced from above.

In the choir area two narrow-beam and two wide-beam reflectors using 300-watt lamps are mounted behind columns and directed toward the altar. Four indirect reflectors with 500-watt lamps are used to light the choir vault. Four similar units are mounted on the cornices of the columns at the center of the transept.

Thirty wrought iron ceiling fixtures with four 60-watt lamps and white flashed opal glass panels are located under the first balcony, the second balcony (organ balcony), side altar and balconies.

Lighting level is an average of 8 footeandles in the nave and ranges from 15 to 20 footeandles in the choir area.

Installation is by J. P. Rousseau, Lighting Specialist with Southern Canada Power Co., Ltd., Montreal, Que., and was his entry in the Montreal Section's MMILJ contest.

2. First Methodist Church

Contemporary—but not *too* contemporary—was the desire of the congregation of the First Methodist Church of Niles, Ohio. Recessed lighting for general illumination seemed a good solution, with accent lighting to highlight the focal area around the altar.

Low-brightness square units with prismatic concave lenses, using 300-watt incandescent lamps have achieved the objective of "conservative modernism."

Four of these units are recessed in each of five bents over the nave and six in the beam over the altar area. Lenses are of tinted glass for good color rendition. Additional general lighting is provided by a cove, using warm white deluxe rapid-start lamps, along the west wall of the nave and chancel.

Cove lighting is also used in the narthex and foyer, and three recessed square downlights mounted over the entrance to the nave.

Illumination level in the nave is 12 footcandles and at the chancel 38 footcandles. All lighting equipment is on motor-operated dimmers with control switches at the choir, the clergy stall (which location can be reached by the organist) and at the head usher's station.

Architects for this installation are Harold E. Wagoner, Philadelphia, Pa., and Donald Lloyd Bostwick, Niles, Ohio. This entry won first prize for Mr. Bostwick in the Cleveland Section's contest for My Most Interesting Lighting Job, and placed second in the Great Lakes Regional competition.

3. Salem Lutheran Church

Strictly modern in design, the Salem Lutheran Church in Minneapolis found unanimous acceptance for its lighting system from the congregation, architects and general public.

There are six large fixtures in the nave, each equipped with one 500-watt R52 flood for downlight, and two 40-watt auxiliary uplights. These units are suspended on 16 by 16-foot centers at a height of 19 feet from the floor. In addition, two similar units are located over the balcony, each one with one 300-watt downlight and two 40-watt uplights. Bottoms of these fixtures are cut on a 15-degree slant to provide shielding for the congregation's normal viewing. Under the balcony, eight 150-watt drop lens units are recessed in the flat ceiling on 9-foot centers.

The ceiling-mounted fixtures on the soffit and in the choir area were designed to match the contour of the larger suspended fixtures. They are equipped with 200-watt lamps and low-brightness wide-spread lenses.

The chancel with its curved chancel screen presented an opportunity for dramatic highlighting on the ornamental wood embossing. Sixteen annular-ring type 150-watt PAR-38 units on 3-foot centers are mounted one foot away from the curving screen. Three adjustable recessed spots cover the white statue on the screen and the altar. The pulpit and lectern lighting is by an annular-ring fixed 150-watt PAR-38 recessed directly over each position, and one bullet spot mounted in front of the first beam for each location.

Illumination levels in the various areas are: Front of nave and balcony — 18 fc at pew level; area under balcony — 20 fc at pew level; choir space and area under soffit — 25 fc; chancel — 35 fc; altar area — 70 fc.

The entire lighting system is controlled by four dimmers at two operating locations. Three, at the head usher's stations, control three manual auto-transformer type dimmers for the 4000-watt nave, the 2000-watt chancel and 2000-watt choir circuits. The fourth dimmer, of the wall box type, is in the pulpit and controls pulpit and lectern circuits.

An interesting architectural problem was solved in the wiring for the lighting installations. As in many contemporary churches, the roof construction consists of 2-inch planking, insulation and the roofing material. A false purlin, installed by the general contractor, is used to provide a concealed accessible means of distribution for the lighting service. The top of the planking was routed out to conceal the conduit from the purlin to the outlet; access doors are located at each junction box.

Architect and Engineer for the Salem Lutheran Church are Lang & Raugland; Electrical Contractor, Harris Brothers. Lighting is designed by Charles J. Duepner, of B.M.D. and R., Minneapolis, Minn., whose entry it was in the Twin City contest for MMILJ.

Dramatically highlighted crosses in the narthex will, at some future date, be replaced by a mural. Effective lighting was considered vital and took precedence over other forms of decoration.

Nave — with accent lighting only.

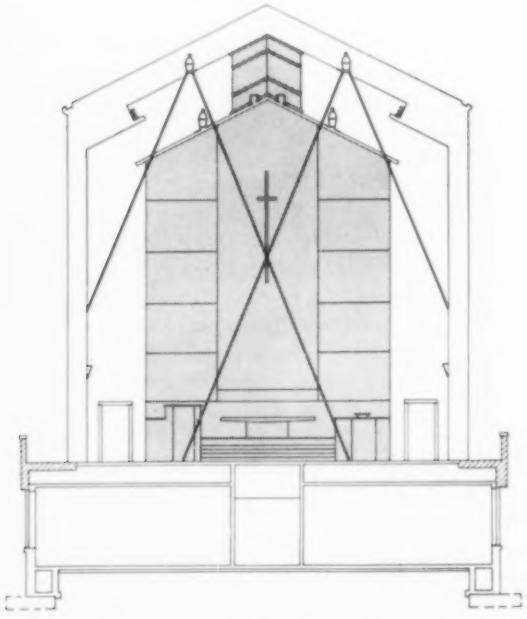
4. Westminster Presbyterian Church

Contemporary design was the choice, by a four to one vote, of the congregation of the new Westminster Presbyterian Church in Charlotte, N. C. That is, a contemporary design conservative in its general proportions.

The building site is a triangular plot in the fork of a busy intersection. The grade drops 25 feet from the intersection, so that there is a full floor under the auditorium with grade level entrances to the side street. This lower floor is 12 feet wider than the auditorium or nave, allowing a six-foot wide terrace on each side.

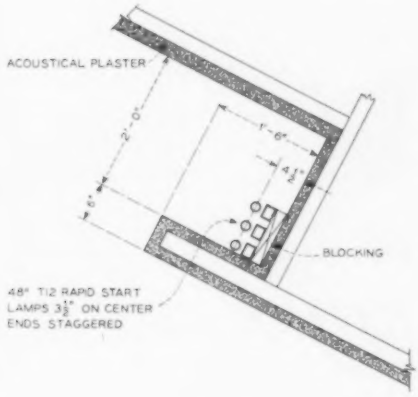
Orientation of the site influenced the design of the building. The congregation faces 18 degrees east of south, which is the mean location of the sun during usual hours of church service. Direct rays of the sun are excluded by the blank south wall and the recess of the windows. The side windows of blue-tinted heat-absorbing glass are 4 feet wide by 40 feet high, set in a 2-foot reveal to keep out the sun as it swings from southeast to south. Walls are furred to 2-foot thickness on the sides of the ceiling to conceal air-conditioning ducts and the legs of the rigid steel frame.

The front elevation, facing the intersection, is largely plate glass — two 12-foot wide, 40-foot high panels with three glass doors, on each side of the center tower. This being a northern exposure, the



Recessed baffled downlights with auxiliary PAR spots are focused on chancel and pulpit, and two front spots criss-crossed to pulpit and lectern.

Baffled downlights and cove lighting provide general illumination in nave.



glass area is not a large load factor in the air-conditioning system.

In the narthex, general illumination is from four recessed baffled downlights using 750-watt lamps. On the wall opposite the doors, a pattern of three crosses is dramatically highlighted by a recessed adjustable 300-watt or R56 flood unit. Bracket lights under "Come Unto Me" have clip-on louvers and satin aluminum finish and use one 150-watt R40 flood downlight and one 75-watt PAR30 for upward light. This wall is of redwood stained brown; both side walls are built entirely of brick in a rich tan shade; floor is of grayish blue-green slate flagstone.

The nave of the church is daylighted by the 40-foot high windows to an average of 68 footcandles in the front of the nave and 37 footcandles under the balcony. The vertical effect produced by the high high narrow windows and the paneling is emphasized by the apparent reduction of ceiling width. This was done by peaking the ceiling in the center and dropping the sides by two feet. The dropped sections provide space for the air-conditioning ducts and also a cove for general lighting.

For night-time use, or for very dark days, general lighting is provided mainly by the coves, which use three rows of continuous strip with 40-watt deluxe white rapid start lamps. Recessed baffled downlights, relamped from either above or below, use 300-watt lamps at the back of the balcony, 500-watt lamps above the first row and 750-watt lamps over the nave proper. A fourth pair of these units, with an additional built-in auxiliary 200-watt PAR46 spot is focused directly on the chancel and the pulpit, while the front spots are criss-crossed to pulpit and lectern. Two spots focused on the cross are recessed adjustable fixtures using 200-watt PAR46 spotlights. Wall bracket lights, designed and built on the job, complete the lighting of the nave proper.

Estimated maintained levels in the nave are 10 to 15 footcandles from downlights and cove and about 3 footcandles from the cove alone. Initial measured levels were 12.6 footcandles in the nave, 12.5 under the balcony, 14.6 on the balcony, 15 at the chancel and 32 and 30 at the lectern and pulpit respectively.

Side walls of the nave are finished in a bluish green shade, called elf green. The chancel is finished in a natural mahogany matching the furniture, woodwork and pews. The velvet curtain with the highlighted cross is a temporary substitute for a planned mural panel showing the ascension figure of Christ. Money was not available at the time for both the mural and the proposed lighting, and all concerned felt that the lighting was of vital importance. A similar panel in the narthex was also postponed. Another proposed addition to the chancel area at a future date is a continuous chancel behind the vertical fins at the windows, with 150-watt lamps on alternate circuits in colors of blue, green, yellow and red from top to bottom, aimed at the ceiling.

Each lighting system is on individual automatic

dimmer control, from either the pulpit or the ushers' station off the lobby. Each of these stations, and the organist also, has signal lights for communication with the others.

Floodlighting of the exterior is from two 1000-watt clear-lens wide-beam floodlights. The lower portion only of the steeple is lighted by four PAR-38 floods, at the behest of the architect, who did not wish the lighting to extend to the top. Since the intent of the lighting was to fulfill the architectural plan, his desire was complied with.

Architects for the building were James A. Stenhouse and Milton Sadler; Electrical and Illumination Designers, T. Llew. Cordle and Ben Weinreb of J. N. Pease & Co., Charlotte, N. C. The installation won for Messrs. Cordle and Weinreb the second prize in the Tar Heel Section's contest for My Most Interesting Lighting Job.

5. Italian Church

Comparatively high levels of illumination were desired for the Italian Church, Eveleth, Minn. — 45 footcandles maintained in the main auditorium, 75 footcandles for the side altars and 100 footcandles for the main altar area.

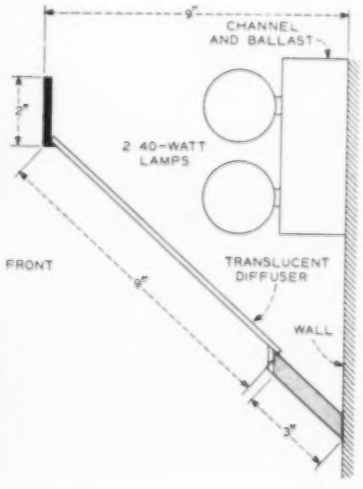
The main auditorium is 67 feet 8 inches by 30 feet in area with a 23-foot ceiling height. The ceiling is painted pale blue, offset by a white border. Behind the main altar are red draperies. Upper walls are an off-white and the lower walls a marbelized surface.

A specially constructed valance was constructed for general lighting, with a closed bottom, open top and translucent diffuser on the front. Twenty-four two-lamp 40-watt units are used, providing the desired 45 footcandles.

In the left side altar, where the statue has red garments, two 150-watt red floodlights are used, and two similar units, one blue and one white, in the right side altar where the statue has blue garments. Five floodlights provide 100 footcandles in the main altar area.

Lighting designed by A. K. Seckinger, Minnesota Power and Light Co., Eveleth, Minn.; this installation won first prize in the Twin Ports Chapter's contest for My Most Interesting Lighting Job.

Detail (below) of valance.



6. Shearith Israel Synagogue

The main room of worship at Shearith Israel Synagogue is basically an equilateral triangle in shape, and will normally seat 700 people. At the rear of the room, an 80-foot wide by 20-foot high expanse of doors may be folded back electrically to include additional room for seating during High Holidays when attendance up to 2200 is accommodated.

General lighting of approximately 30 footcandles is provided by recessed, ellipsoidal, specular Alzak aluminum reflectors with 200- and 300-watt lamps. A switching system permits lower levels of 5 and 10 footcandles when desired. The aperture of 6½ inches is just large enough for re-lamping by lamp stick.

The central 12-foot wide by 20-foot high stained glass window is illuminated by eight fluorescent strips mounted on the back of the ark, and three 500-watt spots from a cove at the ceiling. This produces a beautiful effect from outdoors as well as inside, for the window is on a side street and is visible a block away on this approach to the temple.

The choir loft is located behind the right-hand section of the reeded screen which extends to either side of the bema and ark. Here choir members cannot be seen by the congregation, but can see the cantor through the screen and follow his directions. A lower level of shielded light is provided for the choir.

A small chapel seating 90 people, is lighted to 15 footcandles from recessed downlights using 200-watt lamps. Cove lighting and concealed strips supply a brighter 50 footcandles at the altar and central ark.

Other areas in the synagogue include administration section, classrooms, social hall, bride's room, washrooms and a youth canteen which were relighted in suitable fashion for those areas.

This installation won second prize for J. C. Persons of George L. Dahl, Architects and Engineers in Dallas, Texas, in the North Texas Section's contest for My Most Interesting Lighting Job.

Small chapel is another area in the synagogue. Others are administration section, classrooms, social hall, bride's room, washrooms, and a youth canteen.

7. Christ King Church

Christ King Church is a new building in Georgian design, to fit in with the mainly Colonial architecture of Wauwatosa, Wis. Both interior and exterior lighting are used to complement its simplicity in style and decor.

An outstanding feature of the interior is the golden cove ceiling (metal tile with gold finish) illuminated by the 96-inch T12 fluorescent cove lighting. Recessed downlights in the ceiling use 1000-watt lamps.

Another decorative element is provided by the special design Georgian chandeliers with both upward and downward components. These are suspended from the lower ceiling area over the pews. Lamps used are 150-watt PAR-39 floodlamps and the downlight is louvered. Levels of from 15 to 25 footcandles are provided over the nave by the combined cove, recessed downlights and chandeliers.

The main altar is illuminated by four 1000-watt recessed downlights. The baldachin (canopy over the altar) is highlighted by recessed adjustable PAR-38 spots, with a level of 150 footcandles on the altar table top. Individual spots are focused on the side altars and the pulpit. Baptistry lighting is by large area silver bowl fixtures, and these same type units are recessed in the transept ceiling.

Stations of the cross in recessed niches are highlighted by concealed fluorescent strip.

Surfaces, other than the pews, which might be touched are of mottled marble or terrazzo, simplifying maintenance.

Exterior lighting of the entrance silhouettes the columns by the use of recessed prismatic lens units. The statue of Christ King is spotlighted by recessed adjustable PAR-38 spots. PAR-38 and PAR-46 spots and floods mounted on the roof make the tower visible for miles around. Floodlighting is in effect 365 days of the year. Maintenance is from roof scuttles near the floodlight locations.

This installation, done in cooperation with architect and consulting engineer, won second prize in the Milwaukee Section's MMILJ contest. It was the entry of E. H. Schaefer, Lighting Engineer, Wisconsin Electric Power Co.

Smaller, More Efficient 100-Watt Incandescent Lamp

By P. B. JORDAN, C. W. PEARSON, and W. H. FISHER

The axial filament construction discussed in this paper results in a physically smaller 100-watt incandescent lamp which produces 6 per cent more mean lumens and operates without exceeding permissible temperatures for paper linings of metal shell sockets. In addition, lumen maintenance is improved. A smaller size 100-watt lamp should inspire new designs of luminaires having higher light output. Some suggested designs are illustrated. In suitable luminaires, a smaller lamp made practicable by an axial filament mounting will be interchangeable with lower wattage lamps of the same size bulb. The increased efficiency and decreased size can contribute toward better lighting.

In 1936 A MILESTONE in our country's lighting industry was realized through the introduction of the coiled-coil filament in the 60-watt general service incandescent lamp. This concentration of the filament, with accompanying reduction in cooling effect of the filling gas, produced a 10 per cent increase in light output. The coiled-coil filament also reduced socket temperatures and decreased bulb blackening, thereby permitting shorter light center lengths and smaller bulb sizes. This made possible at that time the reduction of the 60-watt bulb size from the A21 ($2\frac{5}{8}$-inch diameter × $4\frac{1}{16}$-inch) to an A19 ($2\frac{3}{8}$-inch diameter × $4\frac{7}{8}$-inch).

Following the introduction of the 60-watt CC6 coiled-coil lamp, other types, beginning with the 100-watt in 1938, have been changed to the same construction with accompanying improvements in lamp efficiencies and reduction in size.

Higher Efficiency and Smaller Size By Axial Filament Mounting

There have also been other design improvements in these general service lamp types. However, the axial filament and smaller bulb (Fig. 1) described in this paper represent the most important incandescent lamp development in general service types since the introduction of the coiled-coil filament. The axial filament had been previously introduced in high-wattage commercial and industrial lamps.[1] Its use is now being further extended by incorporating it in the largest volume incandescent lamp, namely, the 100-watt general service type (Fig. 1).

In the 50- to 200-watt sizes of the present general service lamps, the coiled-coil filament is mounted across the axis (CC6). By relocating the filament along the lamp axis (CC8), the pattern of filament radiation and filling gas convection currents become so altered as to produce six per cent greater mean light output and 11 degrees C lower socket shell temperature in the same bulb size. Because of this substantial improvement in efficiency and reduction in the socket temperature, the bulb size of the 100-watt lamp has been reduced for the second time.

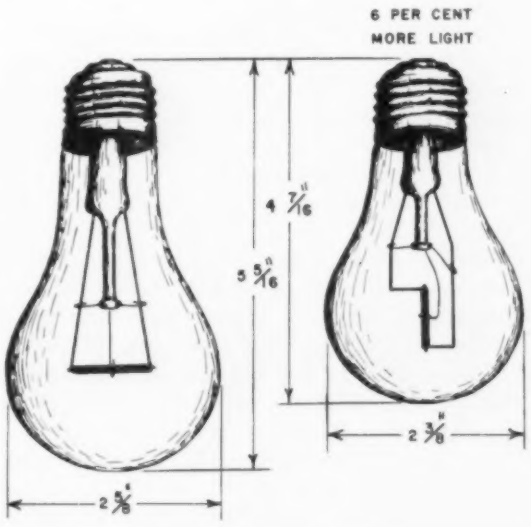


Figure 1. The present 100-watt incandescent lamp and the new axial construction.

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A vertical coiled-coil filament produces higher light output and longer life than a horizontal filament. This condition can be demonstrated with the present standard lamp. If two groups of CC6 lamps are burned with the axis horizontal; one group with the filament oriented vertically and the other group with the filament oriented horizontally, the lamps with the filament positioned vertically will show higher efficiency and longer life than the ones with the filament in a horizontal position. The magnitude of these differences is shown statistically in Fig. 7a involving twenty lamps and in Fig. 7b with ten lamps (see Appendix). These data show two per cent higher initial lumens per watt (0.33) and 21 per cent longer life with the filament in a vertical position.

Problems of Lamp Design

Changing the filament construction from the crosswise to the axial position in the lamp appears, at first glance, relatively simple. However, such a change gives rise to problems of lamp design and manufacture, particularly with regard to filament mounting and initial lamp light-up. It becomes necessary to extend one inner lead wire to a far greater length where it closely parallels the incandescent filament. The leads must be sufficiently flexible to keep from breaking the filament on lamp impact and still sufficiently rigid so they will not distort in shipment and in service.

The change in filament position required a careful working out of such factors as materials and dimensions, shaping parts and providing ample supporting structure and allowing sufficient clearances to provide against damaging heat of the filament. The first light-up of the lamp filament is of extreme importance to its later performance. This operation must be worked out in a manner to insure uniform spacing of turns in the filament and the best arrangement of crystals within the wire.

Through extensive development work, a lamp has been produced that will withstand vibration and drop tests of the packaged lamps without distortion of the inner parts and with a minimum of filament breakage. This test simulates exaggerated shipping conditions. Pendulum bump and drum testing provide further satisfactory information on mount distortion and filament strength after the lamp has burned for part of its life.

There are also a number of tests used to evaluate filament performance in both horizontal and vertical positions with the lamp lighted. Vibration life quality is determined on racks where various amplitudes and frequencies of vibration are applied to the lamps throughout their lives. Vertical bump tests include a solenoid type tester in which a rack of lamps is raised and then dropped onto an anvil thereby imparting shock to the lighted filament. There is a more recent version in which a cam-following roller attached to a rack of lamps rides up onto and drops off the cam so the rack strikes a steel plate, again applying hot shock to the filament. The double-rotary hot shock tester comprises a horizontal cylinder with sockets mounted about its circumference. As the name implies, both the sockets and the drum rotate. In operation with the lamps lighted, the entire head assembly is dropped through a prescribed distance thereby providing a measure of hot shock quality. Pendulum bump is descriptive of the test in which the lamp is suspended on a long cord that describes an arc directing the lamp against a stationary impact board. This test is used to measure both hot and cold filament strength. The pull chain hot shock tester involves the old type socket which is turned on and off by means of a pull chain switch. This is considered a tried and true test to determine the effect of hot shock on the lamp filament. All the above tests are tools that enable building sufficient ruggedness under various service conditions into lamps. The axial filament lamp gives a good account of itself on these tests.

Life-Efficiency Relationships

With the new lamp, the 100-watt coiled-coil filament is mounted on the lamp axis. This relocation requires a redesign of the filament to take advan-

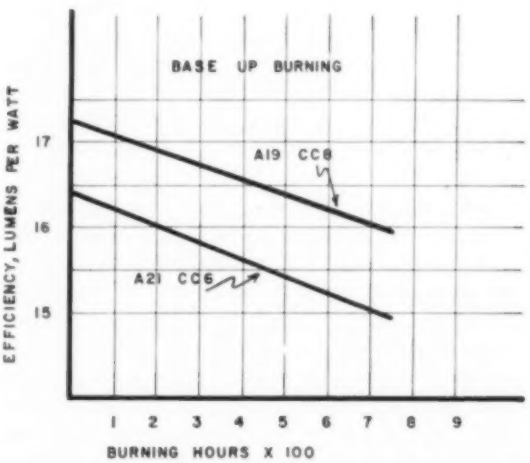

Figure 2. Maintenance of efficiency throughout life showing the axial CC8 filament lamp higher than the present CC6.

tage of the higher temperature at which an axially mounted filament can be operated in a vertical lamp position without sacrificing life. The axial filament lamp in a vertical burning position gives a six per cent mean improvement in light output (Fig. 2). This is due to the hotter filament and the lesser amount of light directed into the lamp base and into the area where evaporated tungsten normally deposits.

In horizontal lamp operation, the axial filament is no longer vertical. Tests on one-hundred lamps constructed with the present 100-watt filament in the axial position in each of three burning positions (see Appendix, Fig. 8a and b) show a reduction of slightly more than one per cent in efficiency and about 13.5 per cent in life in the horizontal position. However, when the axial filament is designed for the higher temperature at which it is capable of being operated, there is an overall average improvement in initial efficiency of about 2.5 per cent over the present lamp when both are burned horizontally.

In designing to take advantage of the improvement with axial filament operation, we gain in efficiency at some expense of life on horizontal burning. However, inasmuch as surveys have shown the preponderant use of the 100-watt lamp in a vertical position, the axial filament construction provides its maximum performance and socket temperature advantages in the most prevalent conditions of service.

Lamp and Socket Temperatures

The essential temperature measurements of two lamps in various open-air burning positions are shown in Fig. 3. In addition, it has been found that in the representative test luminaires, lamps with the axial construction operate at an 11-degree C lower socket shell temperature in the same bulb size in base-up lamp operation than does the present construction. The 100-watt lamp with axially mounted filament in the small bulb does not exceed the 125-degree C socket shell temperature limit, and bulb temperature increases in the smaller bulb are relatively minor.

The average socket shell temperature in representative luminaires is 120 degrees C for the A21 CC6 lamp and 122 degrees C for the A19 CC8 lamp. These data should prove of value in designing fixtures where provision for size and for limiting temperatures are in first order of importance.

For years responsible lamp manufacturers have observed a 125-degree C maximum limitation on the linings of metal shell sockets. Temperature

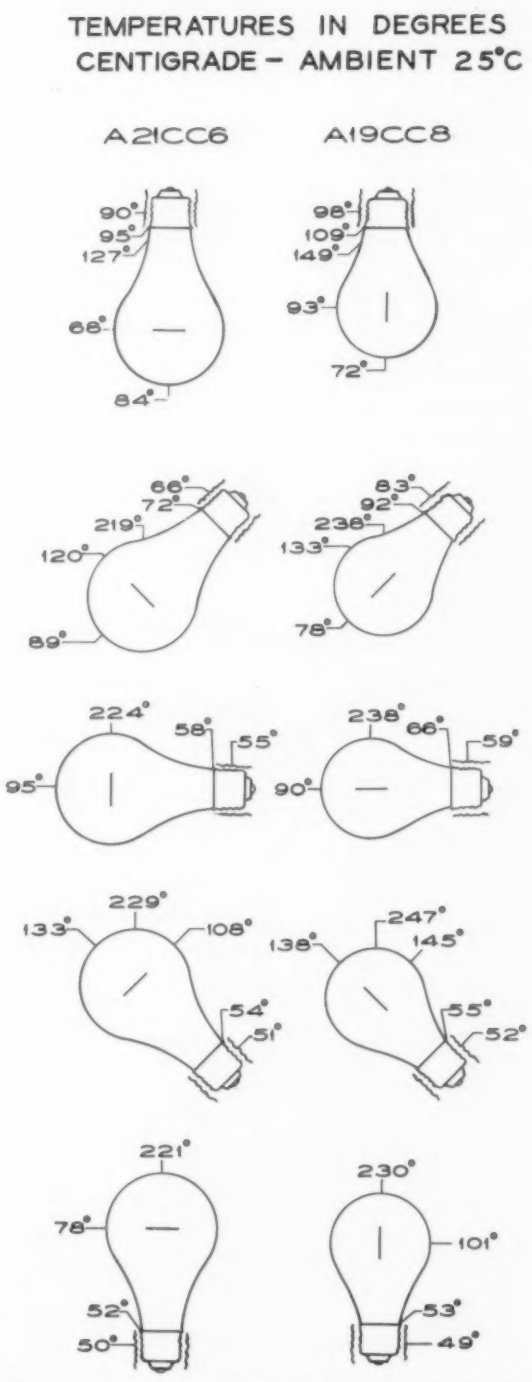

Figure 3. Lamp base, bulb wall and socket temperatures for the 100-watt A21 CC6 and A19 CC8 lamps in open air in various positions of burning from vertical base up to vertical base down.

measurements were made in the standard critical luminaires with lamps of standard filament (CC6) construction and with lamps equipped with the axial filament. These tests showed an appreciably lower temperature, sufficient to permit reducing the size of the 100-watt incandescent lamp and still have socket lining temperatures lower than the 125-degree C limit in properly designed luminaires.

Unfortunately, some poorly designed luminaires have appeared on the market in which the present lamp socket temperatures run above 125 degrees C. Such luminaires may eventually cause the purchaser serious trouble.

As indicated previously, adoption of the axial filament construction causes a sufficient reduction in socket shell temperature to permit reduction of the bulb size (Fig. 1). This makes the 100-watt incandescent lamp one-quarter of an inch smaller in diameter, seven-eighths of an inch shorter, and the lamp has but three-quarters the volume of the present design. It will be the same size as the 50-, 60-, and 75-watt lamps, and but three-sixteenths inch longer than the 40-watt. This should provide for a judicious interchange of wattages which will make for flexibility in lighting levels and in fixture design.

Because of its more convenient size, the 100-watt axial filament incandescent lamp will fit into a greater variety of existing luminaires and should inspire new designs of luminaires for the home and some specialized applications. For example, a cluster of three small lamps could be more easily adapted to a shallow luminaire than a three-lite lamp of the same total wattage and at the same time provide more light. This lamp would also lend itself to a more versatile grouping with ample allowances for temperature limitations of the fixture material, including the socket and its wiring.

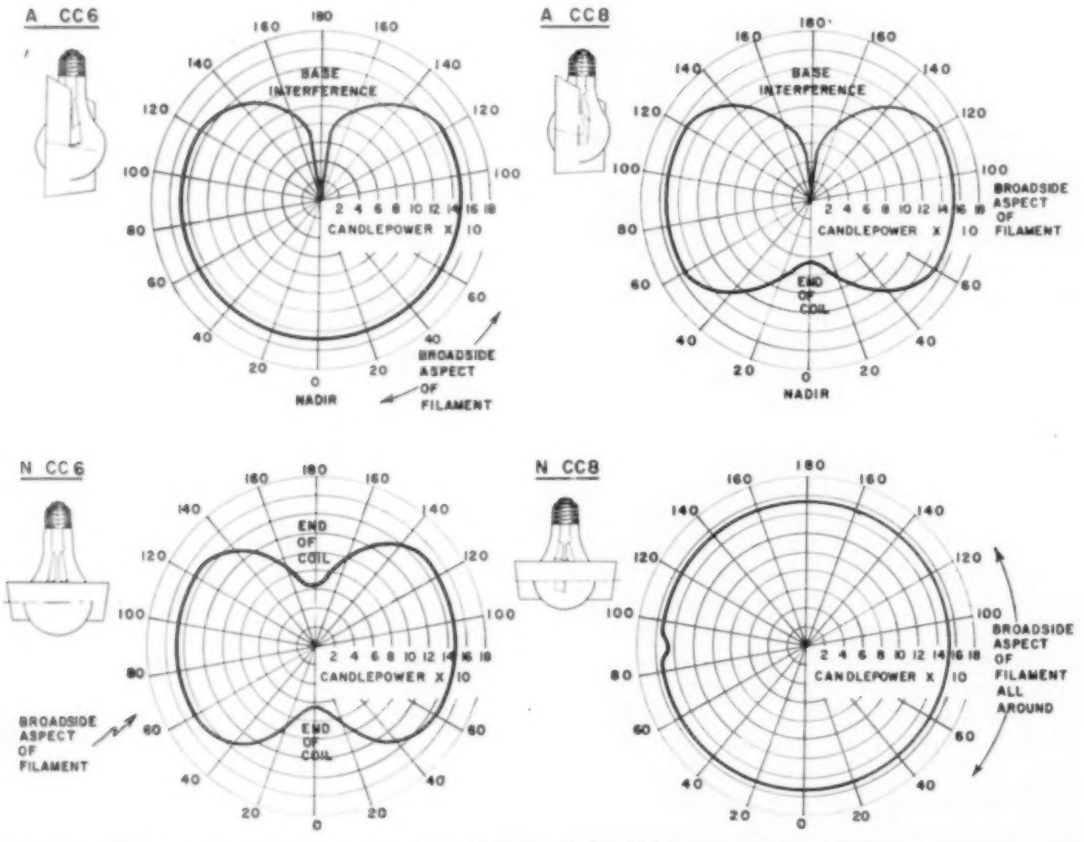

Figure 4. Candlepower distribution curves of the 100-watt A 21 CC6 and the 100-watt A19 CC8. All planes are through the light center of the lamp. Viewed from directions producing no foreshortening of the filament (broadside aspect) candlepower is at a maximum. The small sketches show the position of the planes of measurement relative to the lamp axis and filament.

Pattern of Light Distribution — Axial Filament Lamp Compared with Present Design

As illustrated by the two comparable sets of curves in Fig. 4, the pattern of light distribution is altered by the change from a horizontal to a vertical position of the filament (relative to a vertical lamp axis). In either arrangement there are regions of about 120 degrees opposite the ends of the filaments of coiled-coil inside frosted lamps where the candlepower is reduced as much as 50 per cent. With the present CC6 lamp, this reduction manifests itself at two points in the plane perpendicular to the lamp axis (N-CC6). In the axial filament or CC8 type, the reduction is noticeable when the lamp is viewed from the end opposite the base (A-CC8).

An almost completely uniform distribution is realized with the axial filament lamp in the plane perpendicular to the lamp axis (N-CC8). Here, except for a very minor cup due to shielding of the filament by the long lead, the light distribution becomes essentially symmetrical throughout its 360 degrees. An important advantage of the CC8 construction is the fact that the base and socket come opposite the end of the filament where the candlepower is inherently lower.

In applications of the new 100-watt incandescent axial filament lamp, particularly where fixture designs are involved, the distribution of light from the lamp should be kept in mind. Lumen distribution as well as candlepower distribution is significant; Fig. 5 compares lumen distribution of the two lamps on an average basis for 10-degree zones. The increase in output in directions normal to the lamp axis results from both the higher efficiency and the filament orientation. Thus, with the new lamp there is a greater amount of light flux in the region where the controlling materials in a luminaire function best to redirect or modify the light. An example is a specular reflector designed to provide good concentration with minimum uncontrolled light. With the axial filament there will be a larger proportion of the generated light directed into the beam.

Use of the New Lamp Bulbs for Portable Floor and Table Lamps

In 1934, the Society's Committee on School Lighting completed the specifications for a table study lamp designed for the 100-watt lamp bulb. Its contribution to better lighting was confirmed later, by its acceptance in millions of homes. At that time, the 100-watt lamp bulb had an overall length of $6^{1}/_{16}$ inches, its diameter was $2^{7}/_{8}$ inches and its light output 1510 lumens.

A lighting power pack, Fig. 6, for today's portable lamps is suggested here, using the new small 100-watt axial mounted coiled-coil filament lamps. This arrangement uses three of these bulbs and has an overall height of $8^{3}/_{8}$ inches. Using the 100-watt lamp of 1934, this dimension would have been $11^{5}/_{8}$ inches or $3^{1}/_{4}$ inches more.

Instead of a light output of 1510 lumens from a single lamp, the light output is 5175 lumens, a three-fold increase plus the 645 lumens gain (nearly equivalent to a 50-watt lamp) from product development over the intervening years.

A table lamp, similar to the one shown in Fig. 6, except that the shade was a little deeper, was designed by E. W. Commery.

This combined base and shade is an example of high-fashion, large-scale, but "slimmer" table lamp. The unit, as it appears unlighted, is in the Fall line line of one of the leading manufacturers of moderate-priced mass-produced table lamps. However, in this model, the conventional large harp attached to a single three-way socket has been removed. In its place, under the shade are new parts and the

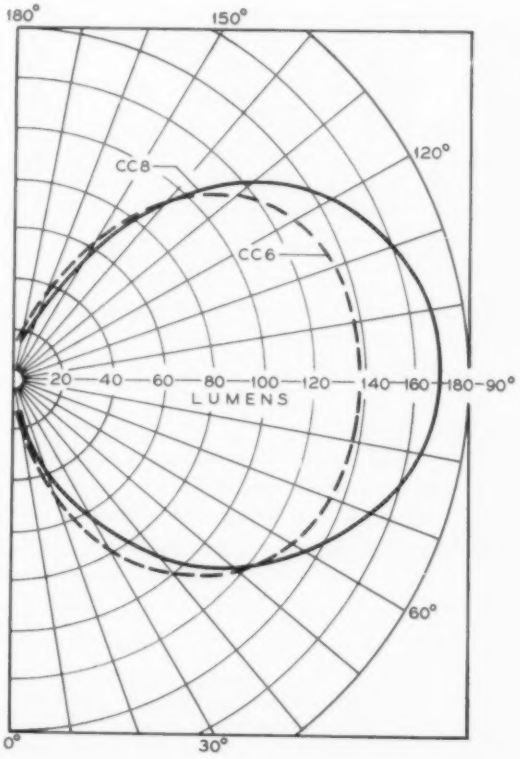

Figure 5. Distribution of lumens about a 100-watt lamp (averaged for 10-degree zones, lamp rotating).
Solid line — Axial CC8 filament (17.25 lpw)
Dash line — Present CC6 filament (16.4 lpw)

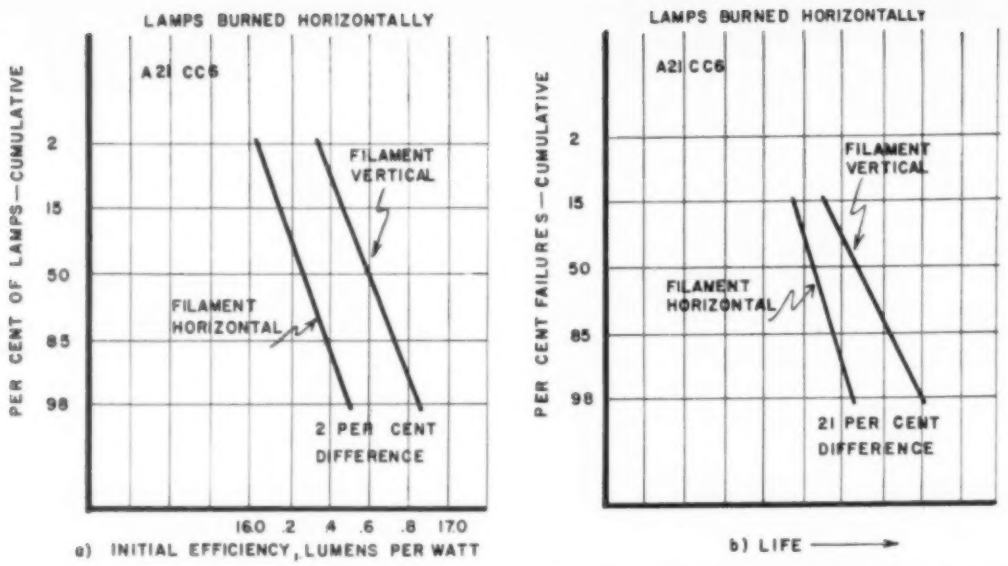

Figure 7 a) Lamp efficiency and b) lamp life curves showing the increase in lumens per watt and life by orienting the present CC6 filament from horizontal to vertical in horizontally burning lamps.

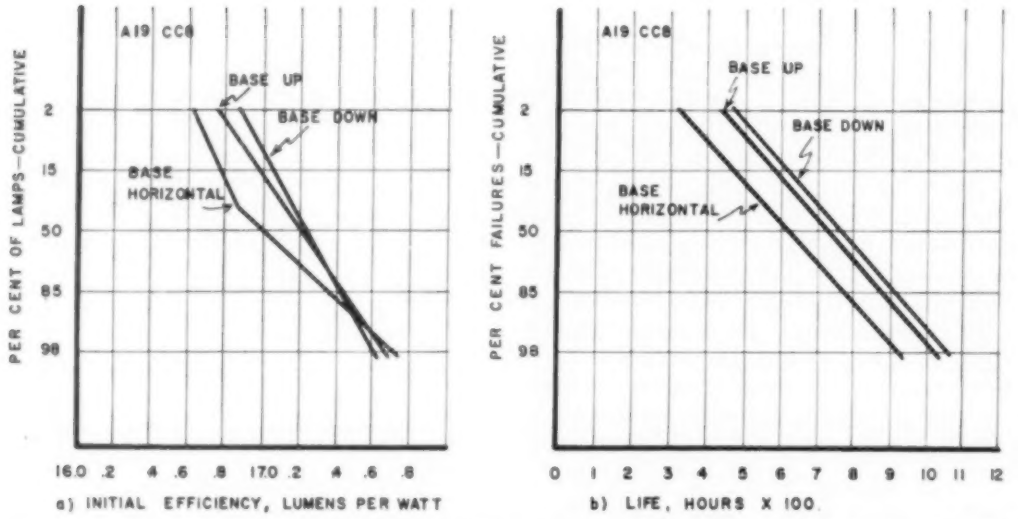

Figure 8 a) Lamp efficiency and b) lamp life curves adjusted to normal life for the vertical showing the effect of burning position on the 100-watt A19 CC8 lamp.

In Figs. 7 and 8, the vertical scale is the cumulative per cent of the sample having a value of initial efficiency less than the figure indicated on the horizontal scale. For example, in Fig. 7a, 16 of the 20-lamp sample (80 per cent) with filament oriented horizontally had efficiencies less than 16.4 lumens per watt and half the lamps had efficiencies less than 16.25. Also in Fig. 8a, for vertical operation of the new lamp, 85 per cent of the 100 lamps in this test group had efficiencies less than 17.45 lumens per watt. The median for the whole group (50 per cent point) is 17.2 lumens per watt.

new 100-watt lamps which can provide new lighting effects.

It is felt that the feeling or atmosphere created in a room by this lamp is one which has long been desired by residence lighting specialists. Two distinctly different lighting distributions are obtainable.

One switch lights a single vertical base-down bulb, for substantial indirect light, though the total shade remains luminous for "conversational lighting," relaxing and relatively dim. A second switch lights two other vertical base-up bulbs for a marked increase — over four times — in downward light with emphasis on the furniture grouping, user, or eye task to be seen. Unlike the conventional single-socket portable lamp, light is not equally proportioned in each system.

The combined lamp bulbs placed on a test plane in accordance with I.E.S. recommendations for reading provide 50 footcandles. A bottom diffusing glare shield reduces specular reflection. A top louvered glare shield is recommended in shades that are ten to twelve inches deep. In deeper shades this may not be necessary. Further, with these bulbs, two of which are burned base-up, an improved lumen maintenance throughout life can be expected.

This table lamp model gives an 11 per cent increase in lumens over one using a single 100/300-watt bulb and bowl and approximately 25 per cent increase in performance due to the greater design efficiency possible in locating the smaller bulbs. Ceilings of average height and typical reflectance, 70-75 per cent, would not exceed 40 footlamberts with this model. This is less than one-third that found with the 100/300-watt bulb, at 300 watts in a diffusing bowl.

In this experimental stage, these devices and their relationships are not rigidly fixed. With some possible refinements and adjustments to fit manufacturing and packaging problems, they are indicative of the progress possibilities in portable lamp lighting design.

In conclusion, the new 100-watt CC8 incandescent lamp will provide:

1. Higher mean light output resulting from:
   a. Higher efficiency filament.
   b. Minimized effect of base and socket obstruction.
   c. Reduced light loss due to bulb blackening.
2. More convenient size.
   Smaller bulb will fit sockets now equipped with 50- to 75-watt lamps, bringing about a new step of interchangeability.

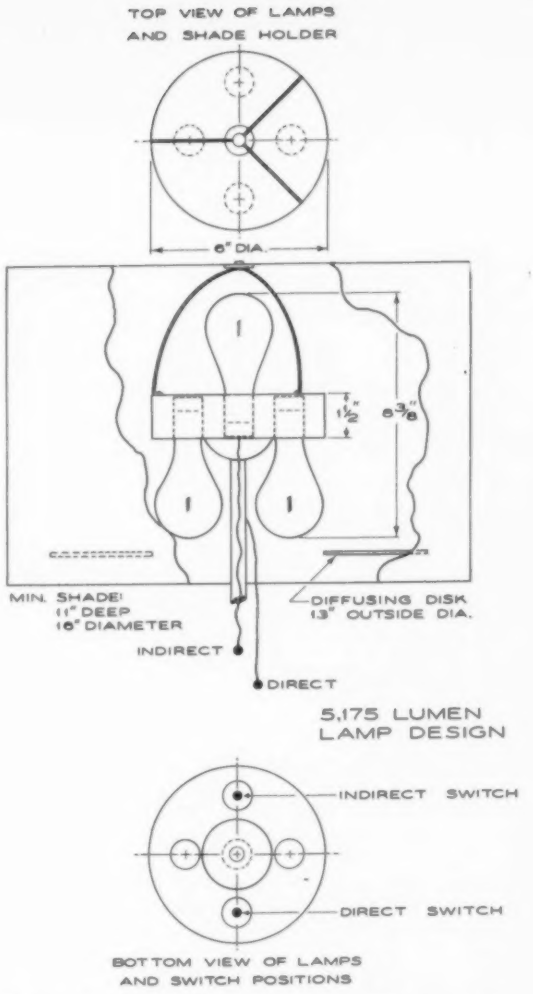

Figure 6. A suggested arrangement of the new lamp bulbs for floor and table lamps.

3. Inspiration for new luminaire designs that will contribute to better lighting.
4. Uniform candlepower, symmetrical about lamp axis.
5. Reduced basic cost of light for 100-watt lamp use.

Acknowledgement

We are indebted to Mr. E. W. Commery of the Residence Lighting group of Application Engineering, Nela Park, for luminaire suggestions.

Reference

1. Pearson, C. W., Linsday, E. A., and Dorsey, R. T.: "Characteristics and Applications of Axial Filament Lamps," ILLUMINATING ENGINEERING, Vol. LI, No. 12 (December 1956).

DISCUSSION

L. E. TAYLER:* The authors have so completely covered the subject of their paper that I find it difficult to add much more than words of praise for their contribution. Only two points come to my mind that may add slightly to the study of the paper.

Data indicate that the new axial construction provides six per cent more light than the present positioning of the filament. The six per cent increase prompted me to determine the increase in light output of previous filament lamp developments. For example, in 1911, the S-30 vacuum lamp with the straight wire drawn tungsten filament provided approximately 25 per cent increase in light over the former pressed tungsten filament lamp. In 1915, the first coil filament lamp was announced which provided 40 per cent increase in light to users. The year 1925 represented a substantial step forward when, for the first time, the coil filament lamp was successfully frosted on the inside of the bulb wall with no decrease in light output. Then, in 1939, the coiled-coil filament lamp was made available with a 10 per cent increase over previous lamps. Now, in 1958, the axial construction of the filament provides a six per cent increase in light output. The point to make here is that this six per cent increase is of a much lower magnitude than former developments. I wonder if this six per cent more light will be noticeable to ultimate users. Also, is there an economic manufacturing advantage in the construction of this lamp which might ultimately reveal itself in a lower cost to the user, plus the additional light output?

The paper also states that with this six per cent greater mean light output, there is an attendant 11C lower socket shell temperature in the same bulb size. In Fig. 3, there is shown the temperature in degrees centigrade at an ambient of 25C at various points on the shell and bulb wall for the conventional filament lamp and the axial filament. However, the temperatures indicated are not for the same bulb size. They are for the A21 in the conventional filament and the A19 in the axial filament. Would it be better to show the temperature differences in degrees centigrade for the socket shell temperature in these two actual sizes?

E. H. SALTER:** With the continued shift to smaller bulb sizes, those of us working with fixtures have been made more and more conscious of lampholder and other fixture temperatures. Mr. Fisher has indicated lampholder temperatures for the present 100-watt lamp using the CC-6 filament and for the new CC-8 filament in the smaller bulb. I wonder if data are available as to the lampholder temperature to be expected if the older CC-6 filament were to be mounted in the newer smaller bulb.

G. A. FREEMAN:† The reduction in bulb size of the 100-watt lamp from A21 to A19 is another step in the trend which was started a few years ago and will continue in still other lamp sizes. 200-watt A25 was formerly PS30, 150-watt A23 was formerly PS25; the present 100-watt A21 was formerly A23 and is now undergoing a further reduction to A19. The 60- and 75-watt A19 types were formerly A21. The 100-200-300-watt A25 three-light lamps were G30.

These bulb size reductions are made possible by improvement in lamp designs such as the change from single coil to the more concentrated coiled coil filaments. They result in increased efficiency. They also permit, physically, the use of higher wattage lamps in existing fixtures.

There is a hazard, however, in higher wattage in existing fixtures which is perhaps greater in the smaller lamps. With larger lamps it is usually a matter of wiring capacity and fuses will blow if existing circuits are overloaded. With smaller lamps, the overheating of paper-lined sockets and existing wiring is slower in its effects and could eventually result in fire. Physically it is now possible to fit the new 100-watt A19 lamp into fixtures that were never thermally designed for higher than 60 or 75 watts. Therefore, considerable responsibility is being placed in the hands of the user. The lamp companies and others in the lighting business have a responsibility to educate the user in regard to wattage limitations of existing fixtures.

W. H. FISHER:* We thank Mr. Tayler for his data on the increases in light output of the household sizes of general service lamps from 1911 to date. In answer to his three questions:

(1) A gain of 6 per cent in light output is not likely to be noticeable to the user. Even the potential gain of 25 per cent in light delivered by portable lamps to the reading plane may not always be noticeable to the user, although it represents a real accomplishment.

(2) The new lamp construction will give the user lower cost light but is not likely to result in a lower cost of the lamp itself.

(3) The 11C difference in socket shell temperature (comparing CC-6 and CC-8 filaments in the A21 bulb in representative test luminaires) was simply stated in the paper rather than shown graphically. This statement was thought to be sufficient to cover this point.

In reply to Mr. Salter, measurements were made on socket shell temperatures with lamps employing the older CC-6 filament in the smaller (A19) bulb. The average socket shell temperature, in the representative test luminaires, was 138C. This is 13C in excess of the 125C limit. In contrast, the average socket shell temperature in representative test luminaires is 120C for the A21, CC-6 lamps, and 122C for the A19, CC-8 lamps. Both of these values do not exceed the 125C limit established for paper linings of metal shell sockets. (See Fig. A.)

We wish to express our appreciation to Mr. Freeman for his interest and comments. He has also given a rather complete review of the reductions in bulb size, of general service lamps, which have occurred during the last twenty years. The point raised in the third paragraph of his discussion has been met every time a bulb-size reduction has been made in the past. Particularly in fixtures of the flush-mounted ceiling types, lamp wattages higher than those approved, and usually marked on the fixtures, should not be used.

*Co-Author.

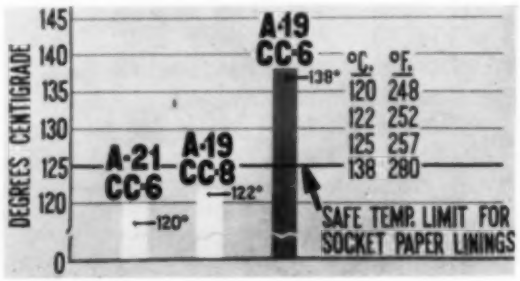

Figure A. Socket shell temperatures — different 100-watt lamp designs.

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**Electrical Testing Laboratories, Inc., New York, N. Y.
†Westinghouse Electric Corp., Bloomfield, N. J.

INSTALLATION AT CARNEGIE MEDICAL CENTER, CLEVELAND, OHIO.

Lighting an Automobile Parking Lot

LIGHTING OBJECTIVE: To illuminate a parking lot to provide an attractive and safe place for shoppers to leave their automobiles and to discourage vandalism and pilfering of the parked cars.

GENERAL INFORMATION: The parking lot is approximately 160 feet wide and 1000 feet in length and is divided into two sections by a cross street as shown in Fig. 2. It is located between buildings and a large portion of the area can not readily be seen from the street. There was constant harassment from vandalism and pilfering before this lighting installation.

INSTALLATION: Thirty-seven Westinghouse type OV-60 street lighting luminaires (IES type IV distribution) with 1000-watt B-H15 improved-color mercury lamps are mounted around the perimeter on approximately 80-foot centers. Twenty-eight of these luminaires are mounted from 30-foot Union Metal Octaflute Steel Standards with 8-foot bracket arms. The standards are mounted on concrete bases 30 inches in height to place the standard above the height of the automobile bumpers. This results in a luminaire mounting height of about 33 feet. Nine of the lumi-

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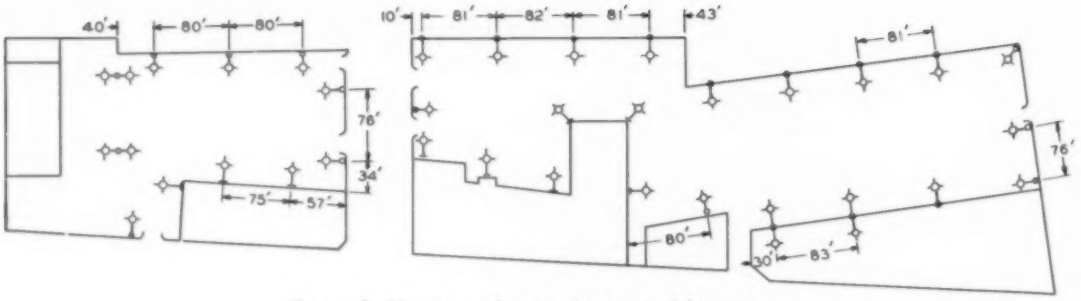

Figure 2. Plan view showing location of luminaires.

naires are mounted from buildings bordering the parking lot. The layout provides an average maintained illumination level of approximately 3.8 footcandles. Festoon outlets for holiday lighting are provided on the standards adjacent to each entrance.

Lighting designed by William A. Mize, Cleveland Electric Illuminating Co., Cleveland, Ohio; lighting installed by The Phillips Electric Co., Cleveland, Ohio.

Lighting data submitted by William A. Mize, Cleveland Electric Illuminating Co., Cleveland, Ohio, as an illustration of good lighting practice and to aid in the design of similar installations.

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Interreflections in Asymmetrical Rooms

By PHILIP F. O'BRIEN

Available empirical and analytical data for the predetermination of luminance and illumination distributions are principally reported for rooms that display axial symmetry. An analytical technique for the prediction of lighting in rooms with luminous inputs and surface reflectances that depart from axial symmetry is outlined in this paper. The Luminous Analogue Computer which is a network or lumped parameter representation of the photic field is used for the numerical results reported here. A cubical room and a large room are analyzed for luminous inputs and reflectances which are non-uniform over the walls, ceiling and floor.

DURING THE past forty years a large body of experimental and analytical data necessary to the calculation of luminances and illuminations in rooms has been prepared for the lighting designer. These design data have been reported largely for rooms whose luminous flux inputs and surface reflectances are located symmetrically with respect to a vertical axis at the room center. Both experimental and analytical studies of lighting systems have considered a uniform flux input at the ceiling and floor and a wall input which is constant at a particular height on all walls of the room. Similarly, the luminous reflectances of the floor, walls and ceiling are uniform over these areas. In order to extend the lighting design-data to rooms whose flux inputs and surface reflectances are not arranged uniformly with respect to a vertical axis of symmetry, an analytical method for the prediction of lighting in these asymmetrical rooms is described in this paper.

Lighting systems that employ asymmetrical luminous-flux inputs and reflectance distributions are widely used in modern lighting. Coves, coffers, troffers, and other forms of built-in lighting elements may be located asymmetrically. Windows, glass-block walls and their associated light controls are asymmetrical light sources. Ceilings can exhibit non-uniform reflectances associated with pipes, structural elements or built-in lighting elements, while the apparent reflectance of the region below the work plane can vary in a non-uniform manner from furniture tops to the cavities between furniture. Although the use of an overall equivalent or apparent reflectance of the ceiling and floor may be justified, the application of this technique to wall areas with reflectances that differ widely may lead to large errors in the calculation of illumination, particularly on vertical planes.

Several extensive experimental studies of flux inputs located asymmetrically at the walls and ceiling have been reported but the results of these studies cannot be extended to cover the range of lighting systems required by modern architectural practice. Daylighting data in rooms with windows located in one or two walls have been published by Griffith[1*] and others. Similarly, a non-uniform flux-input at the ceiling as represented by cove lighting has been considered in an excellent experimental study by Brown and Jones.[2] Experimental studies, even as extensive as those identified above, cannot treat all conditions of flux-input, room geometry and surface reflectance. A comprehensive analytical method for the prediction of the luminous conditions in rooms which depart from axial symmetry is clearly required for the rational design of lighting systems.

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Analytical Methods

Modern analytical treatments of the distribution of radiant flux in a room or enclosure have been based on a continuity or flux-balance expression of the following form:

$$L_1 = L_{01} + \rho_1 E_1 \qquad \text{Eq. 1}$$

$$= L_{01} + \frac{\rho_1}{\pi A_1} \int_{A_1} \int_{A_n} L_n \frac{\cos\theta_1 \cos\theta_n}{r^2_{1-n}} dA_n\, dA_1$$

where:

L_1 — total average luminous emittance of

*Superscript numbers indicate literature references.

finite surface A_1 *including* all interreflections (lumens/ft.^{2})

L_{01} — initial or "input" luminance of surface A_1 *excluding* interreflections (lumens/ft.^{2})

ρ_1 — luminous reflectance of surface A_1

E_1 — total illumination of surface A_1 including interreflections (lumens/ft.^{2})

L_n — total luminous emittance, including interreflections, of a surface element dA_n which may be viewed directly from A_1 (lumens/ft.^{2})

$\cos\theta_1 \cos\theta_n$ — cosines of the angles between the normals to surface elements dA_1 and dA_n and the ray connecting these elements

r_{1-n} — length of ray connecting the surface elements dA_1 and dA_n.

If the emittance L_n is postulated to be uniform over some finite area A_n Equation 1 may be rewritten as follows:

$$L_1 = L_{01} + \rho_1 (L_2 F_{1\to 2} + L_3 F_{1\to 3} + \ldots + L_n F_{1\to n}) \qquad \text{Eq. 2}$$

where

$L_2, L_3, \ldots$ — total luminous emittances of finite areas A_2, A_3, etc., which are viewed from A_1 (lumens/ft.^{2})

$$F_{1\to n} = \frac{1}{\pi A_1} \int_{A_1} \int_{A_n} \frac{\cos\theta_1 \cos\theta_n}{r^2_{1-n}} dA_n\, dA_1$$

The quantity $F_{1\to n}$ is the shape modulus, a dimensionless measure of the shape of A_n relative to A_1. Specifically, $F_{1\to n}$ is the fraction of diffuse flux leaving finite area A_1 that is directly intercepted by finite area A_n. Although the shape modulus for finite areas has been described by Moon[3] in some detail, this parameter has not been employed in the lighting literature to the extent represented by the literature of heat-transfer. An excellent compilation of shape moduli has been prepared by Hamilton and Morgan[4] as a contribution to the analysis of radiant power-transfer systems but the data are equally applicable to the analysis of lighting systems. In a recent paper, Jones and Neidhart[5] have employed the shape modulus in the development of the "Algebraic Method" for the calculation of flux transfer in a room.

Several important contributions to lighting design have been based on Equations 1 and 2. Moon and Spencer[6] have published a comprehensive set of data describing flux distributions in symmetrical rooms. The luminous emittances reported by these authors were obtained by the solution of a set of simultaneous integral equations similar to Equation 1 but the kernel of the integrals was approximated by an exponential function. More recently, Spencer and Stakutis[7] have outlined a technique for the application of Equation 1 to asymmetrical inputs such as windows, but the method has not been extensively developed. European authors seem to favor the finite difference form of Equation 2; for example, Caracciolo[8] of Italy has published data for symmetrical rooms based on the solution of three simultaneous equations of the form of Equation 2. Centeno and Zagustin[9] of Venezuela have suggested that spaces with asymmetrical inputs and reflectance distributions may be represented by a system of equations similar to Equation 2 and an iterative process for the solution of these equations was outlined.

By the rearrangement of Equation 2, Kirchhoff's node equation for radiant-flux flow is obtained as follows (note: Reference 10 outlines a derivation of Equation 3):

$$\frac{[L_{01}/(1-\rho_1)] - L_1}{\rho_1/(1-\rho_1)\,A_1} = \frac{L_1 - L_2}{1/A_1 F_{1\to 2}} + \frac{L_1 - L_3}{1/A_1 F_{1\to 3}} + \ldots \frac{L_1 - L_n}{1/A_1 F_{1\to n}} \qquad \text{Eq. 3}$$

Although Equation 3 is merely another form of Equation 2, it defines an equivalent circuit or network which can be employed to describe a room with any distribution of inputs and reflectances. The application of this network method to lighting systems has recently been applied to both symmetrical and asymmetrical enclosures by O'Brien[10, 11] and Howard.[12, 13] As shown in Equation 3 the potentials of the network are the luminous emittances while the surface reflectances and shape moduli are related to network impedances which are the denominators of the fractions of Equation 3.

The Luminous Analogue Computer

An electrical analogue computer, the Luminous Analogue Computer,[14] has recently been constructed in the Department of Engineering, University of California, Los Angeles. This device is simply a non-planar network of variable electrical-resistance elements which are interconnected according to ten simultaneous equations similar to Equation 3. The schematic diagram, Fig. 1, of the Luminous Analogue Computer shows variable electrical power-supplies that are used to set a current input proportional to a luminous flux input at a surface which forms one part of the boundary of a room. If a surface does not supply a direct luminous flux to the room, the input or boundary node

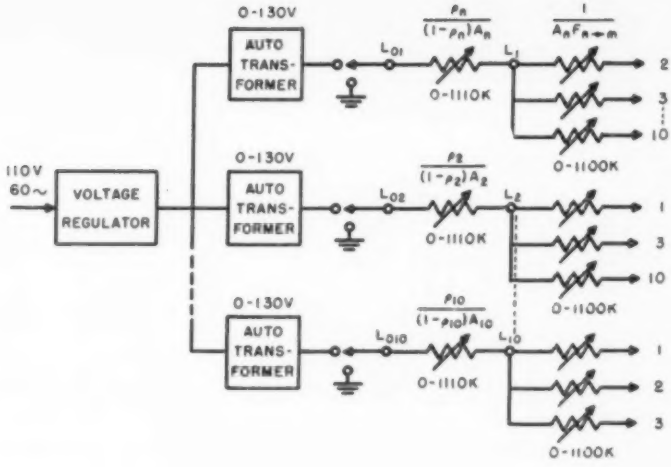

Figure 1. Luminous Analogue Computer of the Department of Engineering, University of California; dashed lines indicate a repetition of identical input units to a total of ten; variable resistance elements expressed in kilo-ohms.

representing that surface is connected to ground potential. As shown in Fig. 1 a variable resistance proportional to the surface reflectance ρ_n (note: surface reflectance resistance of area A_n equals $\rho_n/(1-\rho_n)A_n$) is located between the input node L_{on} and the total luminous emittance node L_n. This reflectance resistance is zero for a black surface and infinite for a perfectly white surface. The infinite resistance setting is obtained, in practice, by opening the circuit between the input and total emittance nodes. On the right side of Fig. 1 the variable resistors which define a room geometry are shown to be located between the total luminous emittance nodes. Because the shape modulus can vary between zero and unity the geometrical resistor (note: the geometrical resistor connecting total emittance node L_n to node L_m is equal to $1/A_nF_{n\to m}$) has a minimum value approaching $1/A$ for large surfaces in proximity and a maximum value approaching infinity for small distant surfaces.

An important feature of the analogue or network representation of a lighting system is the clear separation of room geometry from the boundary conditions of surface-reflectance and luminous input. By simply changing the setting on a variable network element the effect on the total lighting system of changing the size, reflectance, or initial luminous input of a surface can be determined.

Asymmetrical Lighting Conditions in a Cubical Room

In order to illustrate the application of the network representation to asymmetrical lighting conditions, the cubical room depicted in Fig. 2 was programmed for the Luminous Analogue Computer. The cubical room was divided into ten surface areas so that the emittance distribution from ceiling to floor on one wall might be computed. Subscripts 2 and 3, as in Fig. 2, refer to the ceiling and floor, respectively, while subscripts 1, 4 and 5 indicate the larger wall surfaces of area equal to the floor and ceiling.

The program for the solution of this problem on the computer consisted in the computation of the geometrical resistances, $1/A_nF_{n\to m}$, and the resistances proportional to surface reflectance, $\rho_n/(1-\rho_n)A_n$. Table I is a list of these resistances with the absolute values which were set on the machine. Because areas A_6 through A_{10} lie in the same plane the shape modulus between these areas is zero and the geometrical resistance is infinite as listed in the right-hand column of Table I. Resistance values on the order of kilo-ohms were chosen so that inexpensive two-watt ratio-type potentiometers could be used in the computer.

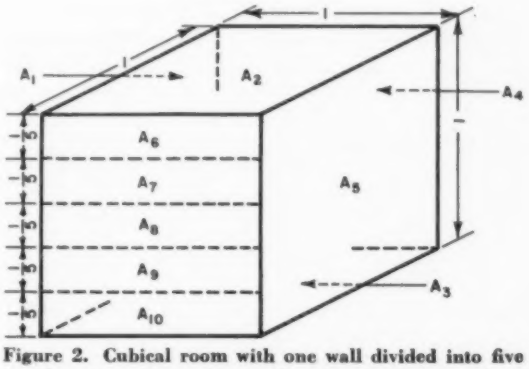

Figure 2. Cubical room with one wall divided into five equal areas; A_2 — ceiling; A_3 — floor; A_1, A_4, A_5 — full-size walls; A_6, A_7, . . . A_{10} — 1/5 wall areas.

TABLE I — Surface Reflectance and Geometrical Resistance Values for the Cubical Room of Fig. 2; Resistances Are Expressed in Kilo-Ohms.

Surface Reflectance Resistances $[\rho_n/(1-\rho_n)A_n] \times 10{,}000$			Geometrical Resistances $[1/A_nF_{n\to m}] \times 10{,}000$ Ft.^{2} Ohms $= R_{n-m}$							
Area	ρ	K-Ohms	R_{n-m}	K-Ohms	R_{n-m}	K-Ohms	R_{n-m}	K-Ohms	R_{n-m}	K-Ohms
$A_1 = 1$	0.8	40	1 - 2	50	2 - 4	50	3 - 7	416	5 - 6	282
$A_2 = 1$	0.8	40	1 - 3	50	2 - 5	50	3 - 8	311	5 - 7	230
$A_3 = 1$	0.5	10	1 - 4	50	2 - 6	129	3 - 9	190	5 - 8	218
$A_4 = 1$	0.8	40	1 - 5	50	2 - 7	190	3 - 10	129	5 - 9	230
$A_5 = 1$	0.8	40	1 - 6	282	2 - 8	311	4 - 5	50	5 - 10	282
$A_6 = .2$	0.8	200	1 - 7	230	2 - 9	416	4 - 6	287	6 - 7	∞
$A_7 = .2$	0.8	200	1 - 8	218	2 - 10	667	4 - 7	240	6 - 8	∞
$A_8 = .2$	0.8	200	1 - 9	230	3 - 4	50	4 - 8	212	⋮	⋮
$A_9 = .2$	0.8	200	1 - 10	282	3 - 5	50	4 - 9	240	⋮	⋮
$A_{10} = .2$	0.8	200	2 - 3	50	3 - 6	667	4 - 10	287	9 - 10	∞

The luminous emittance distribution on the wall from ceiling to floor is plotted in Fig. 3 for several asymmetrical lighting conditions. These cases were chosen to demonstrate the ability of the network representation to predict emittance distributions across a room surface. For Case 1 (Fig. 3) the luminous input is via a uniform ceiling panel with reflectance of 0.8 while ρ wall is 0.8 and ρ floor is 0.5. Because the floor is darker than walls and ceiling, the wall emittance near the floor is about half the value near the ceiling. As indicated on Fig. 3, Case 1 was also computed by Moon and Spencer[6] and their data are plotted as a dashed curve. The per cent difference between these analytical results is less than 10 per cent.

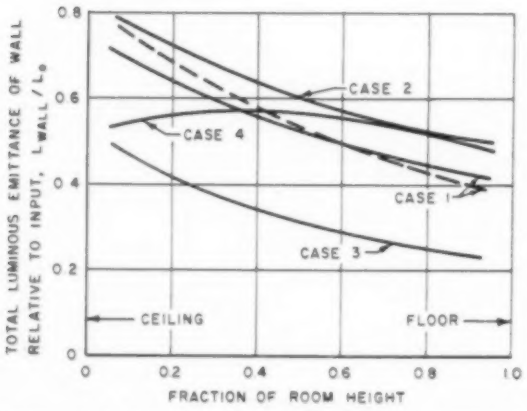

Figure 3. Luminous emittance distribution on one wall $(A_6 + A_7 + \ldots + A_{10})$ of cubical room shown in Fig. 2.

Case 1 — Ceiling input L_{02}; $\rho_2 = \rho_{1,4,5,6 \cdots 10} = 0.8$; $\rho_3 = 0.5$; dashed curve for same conditions as computed by Moon and Spencer in "Lighting Design," (Addison Wesley Press, 1948) pp. 203.

Case 2 — Same as Case 1 except A_4 is perfectly white, $\rho_4 = 1.0$.

Case 3 — Same as Case 1 except A_4 is perfectly black, $\rho_4 = 0$.

Case 4 — One wall input, L_{04}; reflectances as in Case 1.

Cases 2 and 3 for the cubical room of Figs. 2 and 3 indicate the effect of changing the reflectance of one wall A_4 from zero to unity on the luminous emittance distribution at the opposite wall. In this small room the emittance at the wall mid-point is reduced by nearly 50 per cent when the opposite wall is made black.

In Case 4 the luminous input is located at one wall A_4 which is opposite the wall composed of the five equal surface elements. The emittance distribution on the wall as plotted in Fig. 3 shows that the maximum emittance is located four tenths down the wall from the ceiling. This maximum point is nearer the ceiling because the floor reflectance is lower than the ceiling reflectance. With the luminous wall panel of Case 4, the luminous emittance of the opposite wall varies less than twenty per cent from floor to ceiling.

Cases 2, 3 and 4 of Fig. 3 are lighting systems with reflectances and inputs that are located asymmetrically with respect to the vertical axis of the room. Asymmetrical lighting conditions cannot be described by an analytical treatment that postulates axial symmetry. In addition, the room coefficient and similar geometrical parameters are useful for the analysis of symmetrical systems but their application to asymmetrical lighting is limited.

Asymmetrical Lighting Conditions in a Long Room

An infinitely long room whose height is one unit and width is three units (see Fig. 4) was programmed for the Luminous Analogue Computer by the same method used for the cubical room. As shown in Fig. 4 a luminous ceiling panel and a wall panel of a size and location approximating a window are the luminous inputs to the room. The ceiling panel A_6 and wall panel A_4 exhibit identical initial luminous emittances (*i.e.* $L_{01} = L_{04} = 1$) but the total flux streaming from the wall panel is two

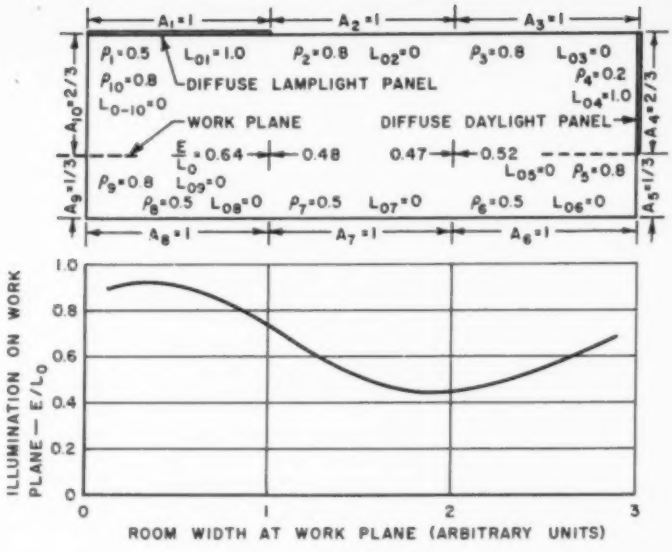

Figure 4. Elevation view of a long room with combined daylighting and lamplighting; initial luminous emittances L_{01} and L_{04} equal unity; illuminations on vertical planes at work plane level expressed relative to initial luminous emittances.

thirds that from the ceiling panel because the panel areas are in this ratio. The floor and ceiling are each divided into three equal areas and the walls are divided into two areas representing a dado and an upper wall or window area. For the case treated in Fig. 4 the reflectances of the non-input areas of the ceiling, walls, and floor are 0.8, 0.8 and 0.5, respectively. The ceiling panel displays an effective reflectance of 0.5 and the daylighting wall-panel has a reflectance of 0.2.

The total luminous emittances of all surface areas of this long room are tabulated as Case I in Table II. Based on these emittance values, the illumination distribution across the room at work plane level was computed and is plotted in the lower half of Fig. 4. In addition to the work plane illumination distribution, the illuminations on vertical planes at work plane level are reported in Fig. 4. These values of illumination suggest that a reduction in the initial luminous emittance L_{01} of the ceiling panel will increase the uniformity of work plane illumination and will also reduce shadow forming conditions which are related to the vertical plane illuminations.

Additional asymmetrical lighting conditions in the long room are listed as Cases 2, 3 and 4 of Table II. The reduction of luminous emittances when the dado areas A_5 and A_9 are made black is shown as Case 2 of Table II. Although the dado areas are relatively small, the emittances of several room areas are reduced twenty per cent when the dado reflectances are changed from 0.8 to 0. Cases 3 and 4 of Table II show the fractional contribution of the ceiling and wall panels to the total luminous emittances of the room surfaces. The emittances of Case 3 were obtained with the input at the lamp-lighting ceiling-panel and the reflectances as shown on Fig. 3. In Case 4 the input is at the daylighting wall-panel.

Conclusions

An analytical method for the prediction of luminous emittance and illumination distributions in rooms with asymmetrical lighting conditions is out-

TABLE II — Ratio of Luminous Emittance to Input Emittance, L_n/L_o, for the Surfaces of the Long Room Shown in Fig. 4.

Case 1 — reflectances and inputs as in Fig. 4.
Case 2 — same as Case 1 except dado areas A_5 and A_9 are black, $\rho_5 = \rho_9 = 0$.
Case 3 — reflectances of Case 1 but input at lamplight panel A_1 only.
Case 4 — reflectances of Case 1 but input at daylight panel A_4 only.

	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
Case 1	1.21	.29	.38	1.08	.32	.26	.29	.38	.49	.58
Case 2	1.16	.23	.33	1.07	0	.21	.26	.33	0	.53
Case 3	1.14	.16	.10	.04	.18	.09	.18	.31	.29	.41
Case 4	.07	.13	.28	1.04	.14	.17	.11	.07	.20	.17

lined in this paper. The variety of light-inputs, reflectance distributions and room geometries which are employed in contemporary architectural practice points out the need for a comprehensive analytical method for the predetermination of the performance of lighting systems. Tabulations of lighting data, whether obtained from experiment or analysis, cannot meet all the needs of the progressive lighting engineer. The solution of systems of linear simultaneous equations similar to Equation 2 of this paper will allow the designer to predict the flux-transfer characteristics of rooms with unique lighting conditions. These equations may be solved with a specialized analogue computer such as the Luminous Analogue Computer or with general-purpose high-speed digital computers. These modern aids to numerical analysis have become routine tools for the engineering designer in many technical areas.

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DISCUSSION

PHELPS MEAKER:* We have reviewed this latest paper with much interest. The following thoughts may be worthy of mention.

One might wish for some tables showing the application of this approach to some typical situations. Three outstanding ones are as follows:

1. The typical variation of wall brightness from top to bottom under indirect or luminous ceiling-lighting.

2. The typical variation of wall brightness from bottom to top with downlighting.

3. The variation of ceiling brightness with filament and fluorescent indirect lighting.

An endless number of tables would not be necessary to show the order of difference resulting from the assumption of complete uniformity over these surfaces. As Mr. O'Brien has said, tables to cover every detailed practical situation are out of the question. But until a general survey has been made, covering end results, it is difficult to know how much the data are needed.

Surely the do-it-yourself aspect of this development has excited the enthusiasm of many listeners. Is this the objective of the author; that many groups start working with such a computer? If so, are detailed specifications to be made available, with instructions such that one might derive the proper dial settings and determine a result, without delving deeply into the mathematical and physical theory on which the analog network is based?

DOMINA EBERLE SPENCER:* The author is to be congratulated on having developed a valuable tool which will be a useful supplement to the interflection method. The results obtainable with the Luminous Analogue Computer are, however, in the class of numerical solutions, that is, only one combination of room shape and reflectances can be analyzed at a time. The method employing integral equations is more powerful: a solution for an entire class of problems is obtained at one fell stroke.

The great advantage of the O'Brien analogue computer is its ability to handle *asymmetrical* problems. When the lack of symmetry is such that the mathematics is quite intractable, the Luminous Analogue Computer takes over with ease.

A limitation on the accuracy with which the O'Brien analogue computer can represent actual distributions of light is that it is incapable of handling any continuous variation. A continuous variation on a room surface must always be approximated by a finite number of uniform surfaces. Fig. 3 indicates that this discrepancy is less than ten per cent in the example cited. However, better agreement with the interflection method would have been obtained if the distribution on all four walls had been permitted to vary. As the number of elements employed in the analogue computer is increased, the accuracy of the approximation to actual distributions of light is improved.

At first sight, the O'Brien analogue computer with its facility in handling asymmetric problems, might be hailed as the key to daylighting calculations. But has it been fully realized how much continuous variation of the distribution on ceiling and floor is needed in daylighting? A clear window is not a perfectly diffusing uniform source of light, nor can it be represented by a finite combination of such sources. Viewed from ceiling and from floor, it has an entirely different character. The treatment of windows containing prismatic glass blocks, louvers, or venetian blinds is likewise complicated. It is only in the very special case of fenestration completely covered with diffusing media that the O'Brien procedure, as outlined here, is directly applicable. This omits the great majority of interesting daylighting problems.

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J. STUART FRANKLIN:* Dr. O'Brien is to be commended for doing pioneering work in the field of electrical analogies for light, the use of standard electrical network theory, and its practical application to our every-day asymmetrical lighting installations.

My primary questions relate to the use of these principles and techniques in outdoor lighting problems. The Luminous Analogue Computer seems to be applicable to the solution of many outdoor lighting problems such as underpasses, tunnels, downtown areas of streets with building fronts, etc. By making some reasonable engineering assumptions dealing with geometry of system, reflectances, etc., perhaps residential and highway lighting systems could be so programmed. Is such possible?

To make allowances for more variables, and thus approximate an actual situation to a greater degree, is it feasible perhaps, on a digital rather than analog computer, to simulate more closely actual pavement reflectance characteristics, fog, haze, etc.? How would the author suggest approaching such a problem?

My final question relates to the Luminous Analogue Computer constructed by the author. What is the approximate cost, let us say, of one of the indentical input units; the actual cost, then, depending upon the total number of input units provided?

ROBERT S. WISEMAN:** Dr. O'Brien is to be complimented for putting to use the modern tools of today's scientist to show how to solve a very practical type of problem which heretofore has been untouchable because of its complications. Certainly, many of the important, unsolved problems in illuminating engineering will be resolved when more scientists begin applying their knowledge and new techniques.

Because of the complications of even solving the physics problems associated with light transmission, only at first were the unprofessional cook book methods practical to use to calculate the illumination levels. Although the interflectance method has been available for almost a decade, I wonder how many have made use of the important contributions of Dr. Spencer and Professor Moon which permit one to calculate the brightness distribution in a room? Certainly, the alert organization which will no longer guess, but will use these modern methods, will profit from their scientific approach to illuminating engineering.

It is to be hoped that scientific techniques for the study of the physiological and psychological effects of the luminous environment will enable the illuminating engineer to approach this part of the problem with the proper professional attitude. The solutions to our problems which are to provide luminous environments for humans will not come easily, and the application of the scientific methods as done by Dr. O'Brien and Mr. Horton and Dr. Zaphyr should be encouraged for the betterment of the life of man, which should be the goal of our profession.

JOHN O. KRAEHENBUEHL:† The author of this paper, and of previous papers published elsewhere, has developed a tool which can be of practical use to the illuminating engineer. To this fact I wish to bear witness with some of the experience gathered at the laboratories of the University of Illinois through investigations made by graduate students. The tool may be relatively inexpensive to yield results within the requirements of practical application. Once the method has been assimilated, with very little effort the necessary brightness of surfaces may be determined, also the average work-surface illumination. This applies to the usual problems with which the illuminating engineer is confronted. With little effort, it may be extended to rooms where the various surfaces have different brightnesses or act as sources.

For unusual shapes and for daylighting many assumptions are made and the design of such lighting belongs to the consultant who is acquainted with analytical methods and has the experience to modify the end results of hypothetical cases and assumptions, in particular when daylight is considered. What is daylight? This in itself is such a variable quantity that any assumption will be even less accurate than the ideal cases assumed in analytical discussions.

At Illinois, studies were being made on using circuit theory in interreflection studies of enclosures when a paper by Mr. O'Brien appeared in the *Journal of the Optical Society of America* (June 1955) which answered the circuit question. Using this basic information, the work was centered upon determining the benefits of this approach to actual design in the field of brightness ratio prediction. The equipment used was a discarded suit-case network analyzer which had been replaced by digital and analogue computers of the most modern type.

In one investigation, a room was selected which was in the

TABLE I — Surface Brightness.

	6-Node			7-Node			Moon & Spencer		
	W	C	F*	W	C	F*	W	C	F*
Room E									
General Diffusing	3.58	6.72	0.81	3.70	6.27	0.80	3.63	6.89	0.80
Indirect	0.61	2.59	0.14	0.68	2.30	0.14	0.62	2.64	0.14
Direct	0.52	0.32	0.23	0.54	0.44	0.23	0.52	0.32	0.23
Room A									
General Diffusing	7.15	9.50	1.54	7.35	9.28	1.53	6.94	9.21	0.98
Room I									
General Diffusing	2.71	6.06	0.44	2.74	5.70	0.44	2.74	6.37	0.42

*W = Wall; C = Ceiling; F = Illuminated Surface.

Room Size:

		Surface Reflectance:	
A	60′ x 80′ x 12′	Ceiling	80%
E	20′ x 30′ x 12′	Walls	50%
I	8′ x 10′ x 12′	Floor	10%

Equipment Distribution

Indirect $I_o \cos \theta_{90°\text{-}180°}$

Direct $I_o \cos \theta_{0°\text{-}90°}$

General Diffusing $I_o \sin \theta + I_o \cos \theta_{90°\text{-}180°} + I_o \cos \theta_{0°\text{-}90°}$

Mounted 3 feet from ceiling on 9-foot centers.

TABLE II — Coefficients of Utilization.

	Network	Moon & Spencer	Harrison & Anderson	Jones & Neidhart
Room E				
General Diffusing	0.51	0.52	0.53	0.56
Indirect	0.48	0.51	0.44	0.50
Direct	0.22 (?)	0.75	0.78	0.79
Room A				
General Diffusing	0.42 (?)	0.73	0.71	0.77
Room I				
General Diffusing	0.17	0.23	0.32	0.29

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**Chief, Research and Photometric Section, Engineer Research and Development Laboratories, Fort Belvoir, Va.
†Colorado College, Colorado Springs, Colo.

medium size class, with equipment of standard type, a room which could readily have been either an office or a classroom — it was the latter. Here none of the brightnesses were uniform, the surfaces did not obey the cosine law; therefore, the results were determined for average conditions. The values could be determined by direct measurement and information was available for developing the proper circuit, the parameters of which were then placed upon the analyzer and illumination and brightness determined. The results checked within reasonable practical application. It is understood that one room does not prove the proposition, but it is indicative of hopeful future developments.

As graduate work,[1] three rooms were selected and three types of theoretical luminaire distributions were chosen. The results are given in Tables I and II. Table I gives a summary of the surface brightness as computed by the Moon and Spencer method, and as determined by a six and seven node network. Table II lists comparative coefficients of utilization as determined by four methods. Again, one investigation does not prove a case, and there are some values which should be carefully rechecked for the deviation does not seem reasonable, but the work does indicate what might be expected from a method which uses an electrical network to represent an illuminated enclosure.

1. Fairbanks, Kenneth E., University of Illinois.

PHILIP F. O'BRIEN:* The author wishes to thank the discussers for their helpful and stimulating comments.

The suggestion that the finite difference or network method be applied to predict the luminance distribution on the walls and ceiling of various lighting systems is made by Mr. Meaker. As shown in Fig. 3 of the paper, the luminance distribution on the walls of a particular cubical room agrees closely with the analytical results of Moon and Spencer. It seems reasonable that other rooms with symmetrical reflectances and inputs will indicate equally close agreement between the two analytical approaches to the problem. However, conditions 2 and 3 of Mr. Meaker's comments clearly define lighting systems with asymmetrical flux inputs to the room surfaces. Typical downlighting systems introduce an initial flux to the walls which is non-uniform with respect to distance down the wall and also across the wall at a particular level. In addition, lighting provided by downlights produces an initial illumination of the floor which is not uniform. Indirect lighting of the ceiling produces a non-uniform input at the ceiling that has been described for restricted cases by Iijima[1] using the Fredholm integral equation. These asymmetrical inputs are most conveniently considered by the use of finite difference equations, and the solution of typical problems is certainly required to gain some concept of the relative effect of changes in the system parameters on the luminance patterns. Some concept of the luminances associated with non-uniform input at ceiling could be obtained by applying a luminous input at surfaces A_7 and A_9 of Fig. 2 of the paper.

More detailed instructions for use of the Luminous Analogue Computer were not included in order to limit the length of the paper. Fig. 1 indicates the order of magnitude of the electrical potentials and resistance values used in the computer. In typical problems, the total current flowing in the network is less than 100 milliamperes because resistances on the order of kilo-ohms are employed. The total resistance of the network is chosen to be small compared to the input impedance of the precision vacuum tube voltmeter used to set the inputs and also to read the output potentials which are directly proportional to the total luminances. A precision resistance bridge is used to set the relatively inexpensive carbon potentiometers. Linear helical potentiometers would improve the elegance of the machine but would also increase the cost by a factor of about ten. Experience with the computer over a period of about two years indicates that a machine with a fifteen-surface capacity would be much more useful than the existing ten-surface model. A rapid means of displaying the output voltages as on an oscilloscope screen would also be a useful addition to the machine, particularly for the synthesis of luminance patterns. For example, the voltages corresponding to the total luminances of the surface elements A_6 through A_{10} of Fig. 2 could be displayed on a screen so as to produce a plot of luminance *vs.* distance down the wall of the cubical room. The reflectance distribution on the wall that would produce a uniform luminance could be quickly determined by merely changing potentiometer settings corresponding to the reflectances. That is, the desired final luminance distribution could be synthesized in terms of the surface reflectances and inputs. The author would be pleased to answer any specific question regarding the details of construction of the Luminous Analogue Computer.

The luminous-emittance distributions and luminous transfer-functions (also termed "interflectance factors") provided by the Luminous Analogue Computer are "in the class of numerical solutions" as pointed out by Professor Spencer. However, numerical solutions are highly useful when the differential and integral equations of classical mathematical-physics resist closed-form solution because of asymmetrical geometries, non-uniform boundary conditions, and non-uniformly distributed internal sources and sinks. The value of numerical analysis is illustrated by the unprecedented development of computing devices since World War II.

The non-diffuse characteristic of flux streaming through clear glass windows or other fenestration with light control devices was not specifically treated in the paper. In 1951, Professor Spencer suggested that for non-diffuse fenestration it is possible "to calculate the actual distribution of light (including interflections) on wall, floor and ceiling, when the direct component of the distribution is known or obtainable from photometric data on a particular type of fenestration."[2] That is, the initial distribution of flux from the non-diffuse fenestration is merely regarded as a luminous input after the initial reflection from each diffuse surface element in the room. Direct flux-transfer kernels or shape moduli are available to aid the calculation of the initial distribution before interflections occur.

Mr. Franklin asks about the application of the finite-difference method to the predetermination of luminance patterns in large outdoor semi-enclosures with one boundary which is, in general, nearly black in effective reflectance. These spaces are ideally suited to analysis by this method because the length is usually many times the width and the geometry may be idealized as a semi-infinite hallway which is effectively a two-dimensional problem. One interesting problem that can be effectively solved with the Luminous Analogue Computer is the prediction of luminances at tunnel and underpass entrances where combined daylighting and lamplighting exist.

The use of digital rather than analog computers for the treatment of non-diffuse reflectances and space attenuators (*e.g.*, fog, haze) is suggested by Mr. Franklin. If non-diffuse reflectances and non-isotropic scattering and attenua-

*Author.

tion of fluids must be treated, the problem is probably best approached with the Monte Carlo technique, which is effectively applied with large scale digital computers. However, if the system properties may be idealized as diffuse and isotropic, analog or digital computers are equally applicable and the effort to formulate the problem for the two types of machines is identical. Cost of machine time, computing time, ease of repetitive calculation, storage modes, display methods and other factors related to economics will probably determine the choice of an analog or digital computer for a particular application.

In answer to Mr. Franklin's last question, the cost of the Luminous Analogue Computer with a capacity of ten surfaces was about $500 for materials and labor in the university shops. This cost does not include the vacuum tube voltmeter and resistance bridge which are necessary to the operation of the machine. Roughly, the total cost of the computer is related to the square of the number of surfaces by the following empirical relationship:

$$\text{Total Cost (dollars)} = A + 20n + 4(n)^2$$

where:

A = cost in dollars of precision vacuum tube voltmeter and resistance bridge

n = total number of surface elements that can be represented by machine.

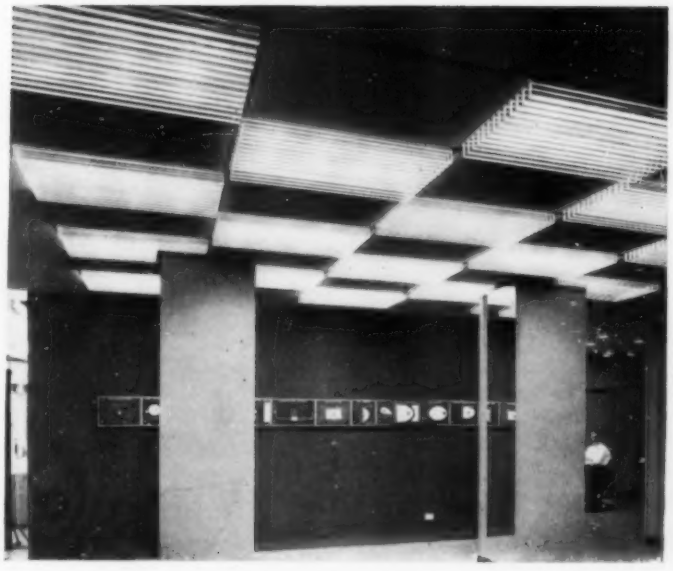
As suggested by Messrs. Meaker and Wiseman, the alert engineering organization with a responsibility for lighting design may wish to apply the finite-difference equations to lighting systems which are not adequately described by existing analytical and experimental data. Whether relaxation methods, digital computers, analogue computers or some other aids, to numerical analysis are employed by the engineer to solve the set of finite difference equations will be determined by the knowledge and economics of the particular design situation. The two major steps in the performance of a lighting calculation are (1) the idealization and formulation of the system in terms of a set of finite difference equations, and (2) the solution of the equations for the set of luminances that constitute the problem solution. Item 2 can be accomplished by a technician with appropriate routine instructions, but Item 1 cannot be effected without a fundamental understanding of the physics and mathematics of the luminous system. Briefly, the Luminous Analogue Computer can be an effective aid to the lighting designer who is grounded in the "scientific basis of illuminating engineering."

References

1. Iijima, T.: "Theory of Inter-reflection between Two Infinite Parallel Planes," *The Japan Science Review — Series I. Engineering Sciences*, Vol. I, No. 1, pp. 9-14 (March 1949).
2. Spencer, D. E., *et al.*: "Glass Block Fenestration and the Interflection Method," ILLUMINATING ENGINEERING, Vol. XLVI, No. 9, pp. 445-447 (September 1951).

Edge Lighting — For General Illumination

This is said to be the only known large-area edge lighting installation in the country. It is one of the demonstrations of lighting techniques shown at the Chicago Lighting Institute. Individual pieces of Plexiglas, 36 inches long, 3 inches wide and ¾ inch thick have been arranged on one-inch centers to form "panels." The spacers are aluminum channel. The plenum chamber above these panels contains 48-inch, 430 ma lamps, placed crosswise to the panels, edge-lighting the plastic, which provides high levels of general illumination.



Preparation kitchen of Norm's Restaurant, La Cienega, California, is designed for maximum efficiency and sanitation. Note extensive use of stainless-steel refrigerators, tables and sinks mounted on wall, refrigerators and ranges mounted on cove base. Lighting is from flush mounted continuous row two-lamp fluorescent luminaires; average illumination after three months service is 50 footcandles. Brightness ratios are well within the maximum limit of 10 to 1 recommended by the IES report. Submitted by J. M. Russell, Editorial Representative, Southern California Section.

Restaurant Kitchens

Shielded luminaires, suspended in the main kitchen (at right), recessed in the waiter pick-up section, add comfort to high levels in the all-electric kitchen of Barraclough's, Los Angeles. The recommended level of 50 footcandles is exceeded in this kitchen, alleviating the problem of high-speed, mass preparation of food and minimizing oversights of defective foods. Submitted by J. M. Russell, Editorial Representative, Southern California Section.

As with many commercial kitchens, ease of maintenance was a dominant factor in the design of the kitchen at the Juvenile Detention Home, Minneapolis. Luminaires are plastic enclosed, semi-recessed, using two 40-watt standard warm white rapid start lamps each. Ceiling is white enamel, metal tile, and walls are ivory glazed tile. Note that luminaire arrangement places maximum light on the critical working surfaces, and contributes a "planned" integration with the stainless steel equipment. Illumination levels vary from 70 to 120 footcandles. Submitted by L. J. Riegert, Editorial Representative, Twin City Section.

At the S & W Cafeteria in Roanoke, Va., the long element of the fluorescent troffer helps, by suggestion, to keep traffic moving. Note that a baffle on the customers' side of the troffer contributes to a pleasing and comfortable effect. Additional incandescent lighting over the food, both in the serving and preparation areas, increases lighting levels here, and contributes a warmth and sparkle. Submitted by C. N. Clark, Editorial Representative, Cleveland Section.

Many of the problems inherent in industrial seeing may also be found in commercial kitchens — and several more peculiar to the kitchens themselves. How-to recommendations for these areas may be found in the IES report "Lighting for Commercial Kitchens," first published in the July 1956 issue of IE. The installations shown here represent several systems for lighting this often neglected area.

Shielded troffers in this commercial kitchen have been arranged in a simple pattern related to the work areas. In addition to adequate levels of illumination, abetted by the light-colored tile surfaces, the system provides a pleasing appearance. Submitted by C. N. Clark, Editorial Representative, Cleveland Section.

A company cafeteria kitchen (Northern States Power Co. in Minneapolis) has achieved a high level of comfortable lighting with a well-planned combination of fluorescent and incandescent systems. With the relatively low ceiling (8 feet), general illumination is provided by recessed fluorescent troffers having dished low brightness lens, and recessed incandescent fixtures with concave glass lens. Illumination levels on the working areas vary from 60 to 70 footcandles. Additional illumination is provided for more critical seeing tasks with supplementary lighting under the range and fryer hoods, vapor-proof incandescent under the range hood, and a plastic enclosed fluorescent unit under the fryer hood. The ceiling is white enamel metal acoustic tile, walls are a beige glazed tile and the floor is a green terrazzo. Submitted by L. J. Riegert, Editorial Representative, Twin City Section.

Outdoor Lighting Design for

By ABE H. FEDER

A Terminal City of ten buildings, planned to accommodate 140 aircraft at one time, is now under construction at the New York International Airport, one of the facilities of the Port of New York Authority. Under this aegis, the new airport has been planned step by step and over a period of years. The International Arrival Building and the two airline wing buildings were dedicated in July 1957; the unit terminals will be completed by 1960. The inception and execution of these plans represent a joint effort on the part of the Port Authority's Aviation Planning Division and its Engineering Department.

The very concept of the airport, in terms of size and structural layout, is a recognition of the extent to which we live increasingly in an airborne age. Not the least of its marks as an airport designed for the future is the floodlighting of its focal point, the Central Terminal Area.

This landscaped oval is 655 acres. Surrounded by an extensive system of roadways, the outer band of the oval contains the landing fields, each attached to one of the ten passenger terminal buildings facing a 160-acre plaza. The International Arrival Building alone is 11 city blocks long. The control tower is 11 stories high. Everything about the Central Terminal Area was necessarily conceived in terms of enormous proportions. What was needed was a floodlighting design to match an architectural design which used space most daringly and purposefully.

The floodlighting of the inner core of the area, the 160-acre plaza (about 6,900,000 square feet) was a particular problem. A design had been worked out incorporating a grid of about 275 poles, 29 feet high, 100-125 feet on centers, and mounted for the most part with four fluorescent luminaires per pole. This required a large number of vaults to act as feeding sub-stations to be spotted throughout the plaza. It was calculated that an average of 1.5 footcandles would be achieved in the plaza, unless more poles were added. Although in keeping with accepted standard practice, the floodlighting design thus envisioned was not satisfactory if the plaza, which contains large parking areas, a mall, a variety of trees and plantings, roadways, and lagoons, was to be efficiently illuminated and still retain its architectural character of vastness and beauty. But no outdoor installation existed that pointed to a better solution.

In the spring of 1955, the Aviation Planning Division consulted the lighting industry regarding

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 9-13, 1957, Atlanta, Ga. Author: Lighting Designer and Consultant, New York, N. Y.

New York International Airport

a lighting design which would incorporate far fewer poles, so that the unity of line in the Plaza would not be broken into tiny segments, and a design which would embody a light source which could provide more intense illumination than an average of 1.5 footcandles. But industry had to forego the challenge on the basis that the means for such a design did not exist, and conventional methods of floodlighting were the only solution. In December 1955, the Aviation Planning Division retained a lighting consultant to study the situation and perhaps come up with a new plan. In addition, he was to advise concerning such points as the floodlighting of the control tower and the fountain lighting, but his main problem was to remain the floodlighting of the Plaza.

Objectives of the Search

The problem of floodlighting the Plaza was essentially the problem of designing a light pattern and components which would achieve the following objectives: (1) both a daytime and night-time appearance which would blend aesthetically with the total architectural design; (2) a general blanket of light that would provide an intense, even illumination in addition to permitting a certain stress on focal points; (3) a minimum of glare for both motorist and pedestrian; (4) a minimum of glare for those working in the control tower, for whom unimpaired visibility was of the utmost importance; (5) a minimum of glare for pilots bringing in their planes; (6) a maximum and economical utilization of power in terms of lumen output; (7) a flexible beam pattern for targetting purposes; (8) a minimum of maintenance on an annual basis; (9) a lighting design which would not be out-dated in the foreseeable future. All this was to be achieved with a minimum of poles and luminaires. Reversing usual procedures, the floodlighting design had to start with the results, the objectives, and not the means. This meant that a theory became a solution before the steps were worked out, or the necessary components brought to life.

The Question of a Mounting Height

The question of a mounting height for luminaires was considered one of the two keys to the problem. Reasoning started from the premise that if several light sources were mounted together at a great distance from the ground to be illuminated, the resulting field of light will remain relatively intact, although within it, the individual lighting units

can be targetted at will. In addition, the higher luminaires are mounted, the more can glare be minimized. Choosing a mounting height was therefore not a question of climbing up from the ground, but, rather, climbing down from the sky.

After much study, a compromise point was determined. Height was brought into a relative position with the ground line by means of such practical matters as safety considerations, maintenance, and the effective distance for directing light. The calculated compromise point was determined as being somewhere in the vicinity of 70-74 feet. The advantages of such a height were obvious: towers ("poles" was no longer an adequate term) about three times the height of the poles once considered could be placed as much as 300 feet on centers, or more, as compared to 100-125 feet, reducing the number needed. In addition, the angle of incidence of light rays emitted from a luminaire mounted at 75 feet to a person on the ground was small enough to assure a minimum of glare. The main disadvantage of such a height was also obvious: a light source would have to be found that could project enough lumens from that distance to the ground to provide an intense illumination.

Figure 2. Towers in completed installation.

The Question of a Light Pattern

Having determined a mounting height, the second key to the floodlighting problem was the question of designing a consolidated pattern of beams most suitable for creating an even blanket of light. Considering the distance between towers, light would have to be thrown at least 150 feet from the foot of a tower, this being the approximate halfway point. In addition, the beam of one luminaire would have to cover a rather large spread on the ground. Without the use of too many luminaires, because of appearance and power requirements, each tower would have to light approximately 150,000 square feet. It was felt that the use of standard PAR- or R-type lamps would involve far too many units.

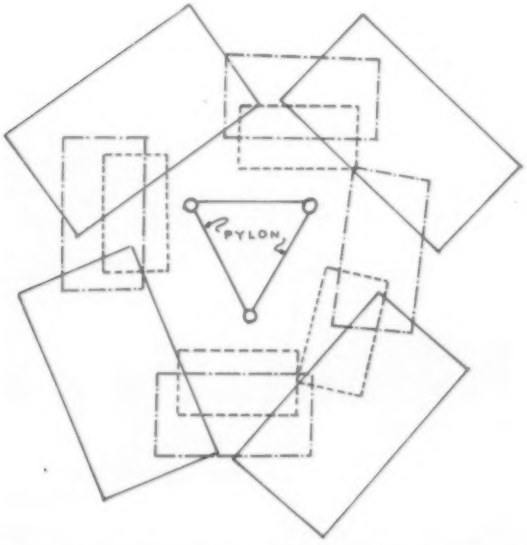


Figure 1. Initial targetting plan of a 12-luminaire tower.
——— Long shot 180 feet from pylon Sp. 195′ x 310′
—·—· Med. shot 140 feet from pylon Sp. 125′ x 250′
- - - - - Short shot 95 feet from pylon Sp. 75′ x 190′

The question of a satisfactory light pattern, as well as of appearance, helped to determine the final tower design. Basically, it was a tripod which evolved, so that luminaires could be mounted at the three corners of the triangle formed by the legs at the top, making it possible to focus them in any desired direction without undue obstruction or protuberance.

Having decided that some of the light would have to be directed at least 150 feet to the ground from the base of the tower, provision would also have to be made for shorter throws, so that the field of light would extend from the center between towers to the base of each tower. Assuming that a tower were mounted with 12 luminaires, and the targetting set without having to consider anything except illuminating the 150,000 square feet circling the base of the tower, the consolidated pattern of beams would

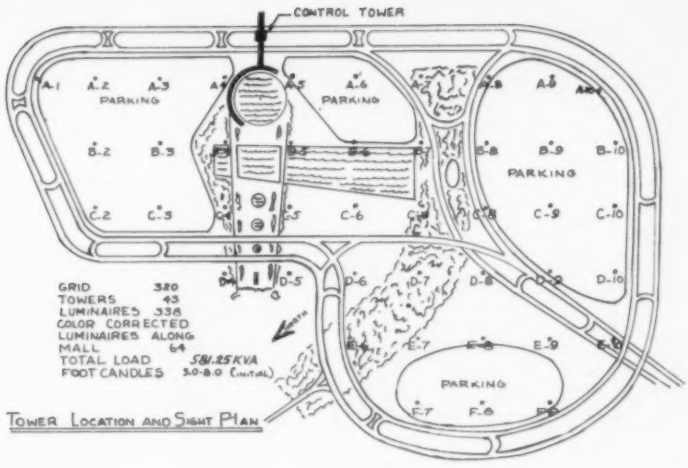


Figure 3. Layout of Plaza showing tower locations.

look something like the layout in Fig. 1. (In actual fact, no tower could be treated so simply.)

It was only after the mounting height and light pattern were determined that the means by which they could be achieved were developed.

Light Source

Concurrent with these studies, a suitable light source was being sought. In general, the search was directed towards a mercury source, since it could supply a large quantity of light in a compact source at a life appropriate for such an application. Efficiency of light production and maintenance of output were also factors in its favor. In the course of exploration, the 3000-watt A-9 mercury vapor lamp was discovered in use for high bay industrial application. In a T-9 quartz tube equipped with spade single-contact terminals, it has an initial output of 132,000 lumens and a rated life of approximately 6000 hours, at five hours per start. The potentials of this form of lamp for doing the job required were seized upon immediately. A mercury vapor lamp of extended length would be more suitable than a single-point incandescent source or a fluorescent source of relatively low output per unit of length. Also, mounted horizontally, this lamp, in a proper reflector housing, could produce the desired wide rectangular (actually elliptical in practice) beam spread on the ground. The photometric curve of this lamp was studied and samples, mounted at 70 feet, were tested at New York Idlewild Airport. The intensity of the light projected at the ground line was highly satisfactory.

Although the principles of this lamp were accepted, the lamp itself was rejected: the housing required for this 55-inch lamp would be too large and unsightly; also, 132,000 lumens represent a great mass of light with which to deal as one beam. With so much light coming from one source, perhaps only two to four luminaires per tower would be necessary to achieve a high level of illumination, but if the desired light pattern was to be effected, each tower would have to be used as a point from which more than two controlled beams were projected. It was decided that a new light source was needed, designed on the principles of the A-9 lamp. As a result, the H1500A23 lamp was developed. With a quartz tube, it was possible to put 1500 watts in a lamp with a 12-inch light center and only $19\frac{9}{16}$ inches overall, even bettering the watts per inch ratio of the 55-inch lamp. This new lamp has the following specifications: T-9 quartz; 1500 watts; 81,000 lumens; 425 volts; 3.9 amperes; spade single-contact terminal; 6,000 hours life at 5 hours per start.

Figure 4. Photograph of lamp.

Figure 5. Luminaire used in installation.

Luminaire

The designing of a fixture for the lamp could not wait until the lamp was being perfected. The crux of the fixture was its reflector, so engineered that the beam projected could be controlled at will. The fixture was to minimize glare and spill, and achieve a good pattern with a low ratio of brightness variation. A specification based on a preliminary design called for the following:

Type: 1500-watt mercury vapor luminaire
Power Required: 1.625 kv maximum, including accessories
Voltage: 440-480 volts, 60 cycles
Mounting: yoke mounting, adjustable
Protection: weatherproof
Expected Efficiency: 55 per cent
Reflectors: Alzak aluminum and aluminum

Certain test procedures were necessarily part of the specification, and underscoring the fact that the fixture had to function satisfactorily at the height of 70 feet, one of the accelerated life tests called for the luminaire to withstand a wind velocity of 125 miles per hour; it was to be subjected to salt spray and vibration tests as well. In addition, the transmitting medium had to absorb all harmful ultraviolet radiation.

As mentioned, the reflector was the crux of the problem. To ensure the desired beam pattern, the specification called for a beam that "shall cover an area on the floor (based on a 70-foot mounting height) of 250 x 125 feet at a point 125 feet away from the mounting pole. It shall also cover an area of 150 x 83 feet at a distance of 60 feet away from the pole. This beam area is to include only the light flux greater than 10 per cent of maximum candlepower." This resulted in a beam spread of approximately 80 degrees horizontal by 28 degrees vertical. The first mock-up was produced for the inspection of Port Authority representatives only three weeks after the final specifications and drawings of the proposed fixture and suggested reflector curves were delivered to the development agent.

Two types of reflectors were called for, the first to be of a specular finish and the second of a diffuse nature, to eliminate the hot band in the beam of a short distance throw. However, only one type of reflector, a specular one, was built in time for the first demonstration, in September 1956. (As a matter of fact, it was not until May 1957, after the first testing of the final manufactured luminaire at the airport itself, that the types of reflector needed for varying distances could be specifically determined and developed accordingly.)

The new 1500-watt mercury vapor luminaire has the following dimensions:

Diameter: 22¼ inches
Body span of trunnion: 28¼ inches
Length of body: 32½ inches
Overall length (including trunnion and cable): 40¼ inches
Weight: 59½ pounds

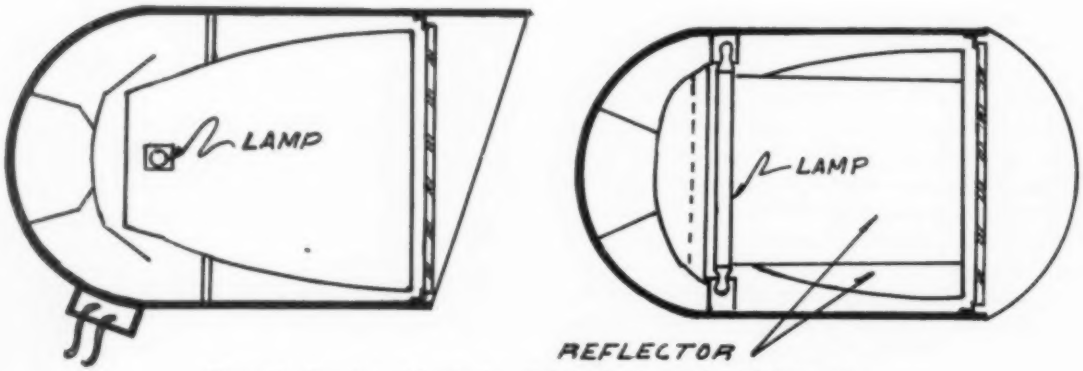


Figure 6. Drawing of luminaire, (left) side view and (right) top view.

Its cover is shatter-proof, weather-resistant glass, and is capable of absorbing radiation below 3,000 angstroms. Ventilation is not artificially induced, but is achieved naturally by adequate luminaire surface area and volume. The fixture and ballast (remotely located) operate at a power factor of 95 per cent. The ballast is designed to provide starting down to −10 degrees F.

Yoke-mounted, the luminaire can be pivoted at 180 degrees vertically and 360 degrees horizontally in relation to the ground. There are also a sighting device for targetting purposes, and a hinged back for re-lamping.

Tower

The tower is made of steel and is 75 feet high. Its three legs, intersecting at a point 37 feet 3 inches from the base, form an equilateral triangle at the base of 8 feet 10½ inches, and at the top of 3 feet 10½ inches. The legs have a 165-degree twist between top and bottom. A platform, of 3½-foot hexagonal shape, is set 8 feet below the top of the arms. Each tower has its own vault below grade, serving as its feeding substation.

Set between the tower legs, the vault is 10½ feet square. Its outer shell is built of reinforced concrete. Each vault contains the luminaire ballasts for its tower, as well as disconnect switches. Conduit is run from the vault, up through the tower legs, to the luminaires. In the wiring and switching, provision is made for half-power condition, *i.e.*, one-half the total luminaires are switched off at pre-determined times. Power to the luminaires is phased out to reduce stroboscopic effect.

The luminaires are serviced from the platform, which is accessible by means of high-ranger equipment. In almost every instance, a high-ranger truck can be driven to each tower by use of the regular roadways. In a few instances, however, special access roads were built.

The Mall Towers

An additional problem was presented by the mall, designed with special tree and shrub plantings and a large circular pool, a large, rather rectangular, lagoon, and several smaller pools. Narrower light beams to dramatize the water and the plantings were desirable. After some study, it was decided to mount improved-color 400-watt mercury vapor lamps below the intersections of the eight towers bordering the mall. The decision to mount these subsidiary lamps (which have R-60 casings), in especially designed housings, on the towers themselves eliminated the need for erecting additional poles to provide lower mounting heights.

Final Light Pattern

The means by which the objectives of the floodlighting design for the Central Terminal Area Plaza could be achieved were now at hand: lamp, luminaire and tower had been evolved step by step. But once more, it was the light pattern which had to determine the use of these means.

The orientation of the towers was determined architecturally. Set 320 feet on centers, a total of 43 towers were incorporated into the plan, about 250 less than would have been required by conventional methods. The consolidated pattern of beams desired was imposed over this grid to ascertain the number of luminaires needed for each tower and the position of each luminaire. A total of 338 luminaires were used in the following manner:

9 towers	12 luminaires	=	108 luminaires
6 towers	10 luminaires	=	60 luminaires
6 towers	8 luminaires	=	48 luminaires
17 towers	6 luminaires	=	102 luminaires
5 towers	4 luminaires	=	20 luminaires
43 towers			338 luminaires

Considerations other than distance also determined the location of each luminaire. Parking areas were of special concern; towers so located were equipped with more luminaires than those on the perimeter of the Plaza, since there was no intent to direct light away from this core. Each tower had a maximum of 12 positions, with a bank of two luminaires, one above the other, on two sides of each tower leg. As a rule, the six top locations were used first, to provide accessibility to the platform for maintenance and to reduce glare.

The ground beam patterns were established on the basis of short, medium and long distance throws. Piece by piece, the approximately 6,900,000 square feet of the area to be lighted were filled in by one or another type of beam pattern. It was by this means that the number of luminaires was set, the number to be used per tower, and the azimuth determined for each of the 338 luminaires. The number and location of the luminaires per tower were further determined by a power budget of which the floodlighting installation was only a part.

Although preliminary test data had been obtained and the characteristics of the specular reflector curve studied, it was not until early May of 1957 when two towers, F-7 and F-8, were erected at the New York International Airport and mounted with finished luminaires that the actual characteristics could be ascertained. Tests were conducted for several nights running, so that aiming distances could be finalized.

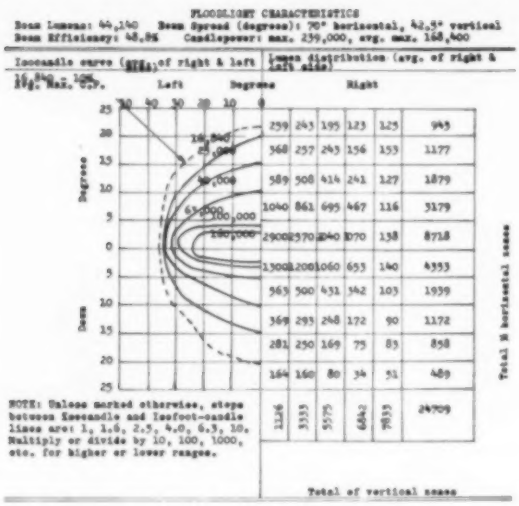

FLOODLIGHT CHARACTERISTICS
Beam Lumens: 44,140 Beam Spread (degrees): 70° horizontal, 42.5° vertical
Beam Efficiency: 48.8% Candlepower: max. 239,000, avg. max. 168,400
Isocandle curve (Effic. of right & left
Lumen distribution (avg. of right & left side)
Left
Degrees
Right
Degrees
Beam
Total in horizontal zones
259 243 195 123 125 945
368 257 243 156 153 1177
589 508 414 241 127 1879
1040 861 695 467 116 3179
2900 2570 2240 1070 138 8718
1300 1200 1060 653 140 4353
563 500 431 342 103 1939
369 293 248 172 90 1172
281 250 169 75 83 858
164 160 80 34 51 489
1126 3333 5575 6842 7833 24709
Total of vertical zones
NOTE: Unless marked otherwise, steps between Kncandle and Incfoot-candle lines are: 1, 1.6, 2.5, 4.0, 6.3, 10. Multiply or divide by 10, 100, 1000, etc. for higher or lower ranges.
Floodlighting Projector Polished 'Alzak' Processed Aluminum Reflector System
LAMP Type: EJ1500A23 Watts: 1500
Light output (test conditions) 90,300 lumens
Operating position: horizontal
PHOTOMETER Type: Polar Axis-Horizontal Test distance: 82.85 ft.
Note: Results are typical only when all test conditions, such as light center position, lamp lumens, etc. are reproduced.

Figure 7. Floodlight curve for specular reflector.

The luminaire with a specular reflector had a beam spread of 70 degrees horizontal and 42.5 degrees vertical, quite different from the one originally specified. The beam of the 1500-watt luminaire was by nature a wide one; it had been the intent to keep the aperture of the fixture as small as possible to cut spill and to keep the beam as intense as possible. The practical consideration of efficiency, however, had meant enlarging the opening to a point where the 42.5-degree spread was reached. It was discovered too that the fully diffuse reflector of the same curve projected a beam spread of 95 degrees horizontal and 73 degrees vertical. Aiming distances had to be recalculated so that the long distance throw was aimed at 160 feet instead of 180 feet and the short distance throw at 100 feet instead of 95 feet; the medium distance throw remained at 140 feet. These changes were made to compensate for the much wider beam pattern than had been intended originally. A certain number of changes in the luminaire locations also became necessary.

Still further tests were conducted, with the ground marked at 10-foot intervals, to determine the optimum result for both a completely specular reflector and a completely etched reflector. The completely diffuse reflector was retained for the short distance throw, but a reflector with a heavily etched back and specular sides was developed for the medium throw, and one with a lightly etched back and specular sides for the long throw. Even in the long distance throw, an all-specular reflector would have permitted a hot band of light in its beam.

Preliminary targetting schedules were scrapped and a new one plotted, using wherever possible the same luminaire locations already established. In the final plan, there are 93 long distance throws, 159 medium distance throws, and 86 short distance throws. An overall design pattern was established for all towers, but within this framework, each tower had to be treated individually, depending on its location and the types of area it was illuminating.

Results

Were the original objectives achieved? The results must speak for themselves. Only 43 towers are used where about 275 poles had been considered. But much more than number favor the towers; they are in themselves a contributing design element to the architectural layout, dramatic points of interest in their own right. At a distance of 68 and 71 feet

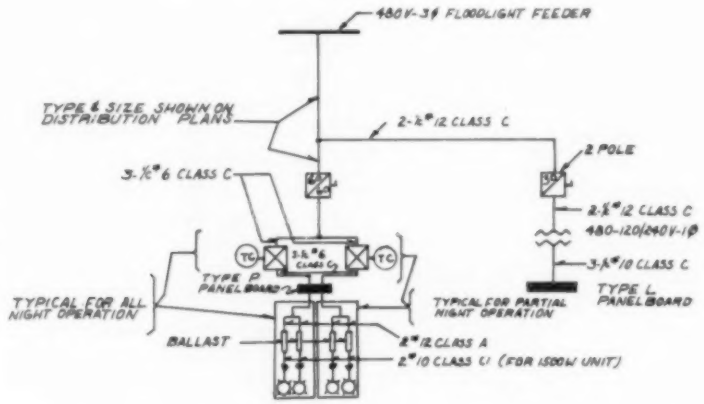


Figure 8. Typical one-line power diagram for tower.

from the ground line, their contours blending with the tower legs, the luminaires appear to be an intrinsic part of the tower rather than appendages. At night, the Plaza of the Central Terminal Area is literally bathed in light. The Plaza layout can be seen distinctly from incoming planes. From the control tower, eleven stories high, the ground is clearly visible. On the ground, the pedestrian or motorist does not move from one patch of light, through darkness, to another patch of light, but he moves in an even field of light. Glare has been reduced to a minimum, another objective achieved.

The illumination levels average from 8 footcandles, to 3 footcandles, and it is possible to read one's watch casually, without twisting one's arm to catch a stray beam of light. The brightness ratio is less than 3½ to 1, still another objective achieved. Nor can there be any question of the efficiency of the lumen output in terms of power consumed. In addition, the maintenance factor, which here precludes any need for re-lamping, barring the unforeseen, in less than a year, is to be considered no mean achievement. The one question of whether the floodlighting design will be outdated in the next few years still remains to be answered. However, considering that approximately 6,900,000 square feet have been illuminated to an average level of 3 to 8 footcandles by means of only 43 towers and 338 luminaires, it is difficult to believe that this design does not belong to the future already.

DISCUSSION

J. K. NEWELL:* I am pleased to have been asked by the author to write a discussion of his able presentation. It was our pleasure to work with him and with the Port of New York Authority on the design for the floodlight, using the H-1500 A-23 lamp for illuminating the 160-acre Plaza. I would like to confine my discussion to that phase of the paper.

The development of the floodlight consisted of making a prototype design and thoroughly testing it before evolving the design for the production units. The object of the design was to make a unit that was aesthetically pleasing but, at the same time, utilitarian. Although we were unable to achieve the ultimate desired in appearance, a compromise was reached that resulted in the form of the final unit.

A linear light source or a tube, as used in this design, would normally make the designer feel that a trough-like fixture with a rectangular door glass would be the best solution, and it could well have offered a good design solution. It was felt that a round unit would be more pleasing in appearance, and in order to achieve a compromise, the resulting design was made round, and the reflectors placed in the unit as if it were trough-like in shape.

We chose a diameter of 22¼ inches for the external casing, and a hemisphere for the rear door opening. This was governed by the overall lamp and lampholder length. The casing was cut on an angle on the front to provide a visor effect to reduce upward glare, and blend with the appearance design. The front door glass consisted of a 20-inch diameter by one-quarter-inch thick tempered sheet glass. The hemisphere in the rear served as a door opening that was hinged so it could be opened from either side for servicing.

Inside the unit, five reflectors, as separate pieces, were selected with parabolic shapes to obtain the desired beam patterns required for the application. The top, bottom and rear reflectors, that were mounted parallel to the light source, made up the greatest contribution to the reflected beam lumens. Two side-reflectors were also employed with less efficient results to re-direct outward, through the door glass, light that might otherwise become trapped within the unit.

Actually, the design sought was similar to a heavy-duty floodlight. The outer casing was made from one-eighth inch thick aluminum sheet and the internal reflectors were separate pieces of reflector sheet aluminum. The door glass on the front was gasketed between two rings, using woven asbestos strips. The rear door utilized a mechanical seal that eliminated any large, high temperature resistant and otherwise perishable gasket. Since the unit employed a clear quartz lamp emitting ultraviolet radiation and ozone, the unit had to be enclosed to guard against the emission of stray light and the materials used had to be carefully selected to prevent deterioration. All materials including the lampholder, insulation and gaskets consisted of inorganic materials. The connections were brought out of the unit into a junction box through glass-to-metal sealed bushings, and thence to a number 14-2 conductor SO cable, the end of which was attached to an electrical plug.

The entire unit was suspended on a trunnion-type mounting that would permit horizontal and vertical aiming, as the author describes. Handles were provided as part of the hinges for aiming the unit and/or opening the rear door. The unit could be targetted or aimed by rifle sights included along the casing.

The prototype or sample was thoroughly tested for photometric performance, humidity, salt spray, vibration and heat, before pursuing the final design. The structural parts of the entire unit were made of alumnium for resistance against corrosion, and the fasteners employed were stainless steel. All aluminum parts were anodized to specifications to withstand marine applications.

Mr. Feder has explained the photometric performance as far as beam spreads were concerned. We can only add that wide variations in beam spread could be obtained by etching one or more of the reflectors to varying degrees.

J. S. HANEY:* The author has described an unusual and spectacular floodlighting system which certainly should impress the night-time visitor to the New York International Airport. For this installation a new mercury lamp and a new floodlight projector were developed. A new lamp ballast was, of course, needed for operation of the mercury lamps.

The author mentions that consideration was given to the use of street lighting type fixtures which would require a large quantity of poles. It was then decided to use a minimum number of floodlight pole locations with a higher mounting height.

No mention has been made of consideration of the use of standard mercury lamps and floodlight fixtures which have

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*Crouse Hinds Co., Syracuse, N. Y.

been available for some time and which afford a much wider choice of beam characteristics. The new 1500-watt mercury lamp which was developed is rated at 81,000 lumens (54 lumens per watt). The standard 1000-watt mercury lamp (AH15) is rated at 55,000 lumens (55 lumens per watt). In addition, this size lamp is available in color corrected types (D-H15 and S-H15). Standard ballasts for these lamps are available from regular suppliers. Lighting fixtures of many different types for these 1000-watt lamps are available on the market including standard cast aluminum heavy duty units and general purpose type units similar in construction to the sheet metal units used for this installation. As many as 12 different beam characteristics are available from 1000-watt fixtures such as these — for example, beam spreads of 72° x 61°, 131° x 37°, 147° x 81° and 98° x 95°.

It is stated that the original design desired was for a beam spread of 80° x 28° but that ultimately units of wider beam spreads were used. It was necessary to refigure the aiming of the floodlights. As on most similar floodlighting projects involving large areas, the aiming is adjusted as required for the job to be done and using the most favorable beam spreads available.

It would have seemed desirable to us to have given strong consideration to the use of standard type 1000-watt lamps, floodlights and ballasts which were already in wide use available from many sources which afforded many more tools to work with than a new special unit with only restricted beam characteristics. It would seem also that the appearance of the floodlight towers with 50 per cent more units of a smaller size would be more attractive. The space required on the tower would be about the same. Better beam coverage could be obtained from a larger quantity of units.

No beam efficiencies of the fixtures as finally used have been mentioned and the actual efficiencies obtained would be of interest as well as the beam candlepowers of these units. It is mentioned that the average level of illumination on 6,900,000 square feet is from 3 to 8 footcandles. Assuming a beam efficiency of 55 per cent, however, which is mentioned in the original design specification, it would seem that each unit would produce 44,550 beam lumens. If all of these beam lumens fell on the area, which we know cannot be done in actual practice with proper aiming, the average initial illumination on 6,900,000 square feet would seem to be about 2.2 footcandles. Using a maintenance factor of 0.65 for average illumination maintained in actual service, this means a maintained average illumination of about 1.4 footcandles. We are wondering, therefore, when the complete area is checked if the average level of 3 to 8 footcandles might not be found to be reduced considerably.

Taking the average illumination reported as 5½ footcandles overall (a median between the values of 3 and 8 mentioned)the total lumens on the area would be 5½ × 6,900,000 or 39,950,000 lumens. This is apparently more than the total lamp lumens available (338 × 81,000 or 27,378,000 lumens).

From the initial reports it would certainly seem that a most satisfactory lighting job has been produced. However, for the sake of technical accuracy, we would appreciate knowing just what actual average illumination is obtained over the complete area.

C. M. CUTLER:* It should be of interest to a great many and particularly to designers that appearance as related to scale and the pattern of such a project was one of the foremost considerations. Solutions on such a premise often require courage to break away from the conventional and more obvious ways of handling such problems. It becomes apparent that more than the strictly engineering aspects are required.

I would like to ask Mr. Feder a few questions:

We all know the higher the units are mounted the less bothersome the brightness of the units becomes from the viewpoint of glare. I understand the 75-foot mounting height was a compromise. How was it arrived at, and if he had to do a similar job, would he select the same mounting height and spacing.

On the Mall towers near the large pool and fountain, improved color reflector mercury lamps were added to some of the towers to dramatize planting and water effects. These are located at about 50 feet on the same towers and some people have mentioned that they appeared glaring and the amount of improved color mercury light added didn't appear particularly noticeable. The question is: wouldn't a few more of the large units at higher points on the towers accomplish about the same result and at the same time maintain the pattern of bright units at the 75-foot level?

Was it necessary after the revised aiming plans were developed to do more than make minor adjustments after the system was all turned on?

There are a few minor errors which I assume will be corrected. On page 145, the T-9 is glass tube and not quartz. On the same page, mention is made of a 12-inch light center. I am sure the author means lighted length.

R. J. PALMER:* I wonder if the author would care to describe the high-ranger equipment. Perhaps I am not alone in being unfamiliar with this type of equipment.

It is indeed a great satisfaction to feel that the summarization of the paper could well be quoted to emphasize the accomplishment. I agree with the author that this design belongs to the future.

A. H. FEDER:** Mr. Haney's points are well taken. Due to the prescribed length of the paper, it was not possible to outline the various tests conducted prior to the decision to continue with the development of the 1500-watt mercury vapor floodlight. Such tests, however, were conducted, and serious consideration was given to several standard floodlights incorporating the standard 1000-watt mercury lamp and ballast. Further, tests were conducted during which the 1000-watt mercury lamp was operated at 1500-watts. The final decision was based on footcandle readings and light uniformity tests of the prototype *vs.* three manufacturers' standard units. The prototype proved superior. An economic analysis based on the best standard floodlight *vs.* the prototype indicated that the prototype offered the lowest cost per maintained footcandle. This was true even though the prototype costs several times more than the standard type.

I might also mention that we were seeking an asymmetric beam pattern, which, to my knowledge, is not produced by any standard unit.

The question of appearance also carried considerable weight in the final decision. I cannot agree with Mr. Haney that increasing the number of fixtures per tower would have proved more attractive. On the contrary, it was our conten-

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*Detroit Edison Co., Northville, Mich.
**Author.

tion that the use of fewer units, made possible by a more powerful lamp than the 1000-watt mercury type, was more conducive to an attractive appearance. I might add, however, that I had every reason to believe the new lamp would produce more than the 81,000 lumens the final product produces. Nevertheless, the economic analysis was based on a conservative estimate of an output of 80,000 lumens.

Mr. Haney's question regarding the total area as given, approximately 6,900,000 square feet, deserves clarification. This is the figure, and a very approximate one at that, of the over-all area of the Central Terminal Plaza which had to be lit. Short of measuring the area foot by foot, a more accurate figure cannot be obtained of the area being lit by the 1500-watt units. The Mall area, for example, is being lit by a supplementary lighting design and thus considerable acreage, represented by the lagoons, is not being lit by the prototypes. In addition, the roadways are not entirely dependent upon the prototype units. Certain grassy areas were deliberately kept at a comparatively low footcandle level. Again, the three to eight footcandles level stated in the paper was based on actual readings taken from the final installation, and did not take into account the maintenance factor. These readings were obtained in all areas used by cars and people, or roughly, about 60 per cent of the total area. However, a "blanket of light" is spread from perimeter to perimeter of the Central Terminal Plaze, and this, with high intensities, where needed, was our aim.

There is one further point to be considered. It was our objective to design a floodlighting system which would produce this even spread of illumination from the ground up to as high a point as possible. It has been my feeling that the basis of lighting up the outdoors at night should be that of literally "pushing back" the darkness above, if possible, most building lines, and of spreading light evenly, not just on the ground, but above the ground. In other words, the ideal would be to able to take for granted the use of the outdoors at night very much as we do in the daytime. This ideal implies higher and higher mounting heights and, obviously, more and more powerful floodlights. It was with this ideal in mind that a more powerful lamp than the 1000-watt mercury vapor type was sought, as a further step toward the trend of the future.

I am grateful to Mr. Haney for his thoughtful comments which pointed up the ambiguities of my paper and provided this opportunity for further clarification.

In reply to Mr. Cutler, I failed to mention in my paper, that the mounting height was limited by the height of the control tower, for it was decided that the light towers should not stand above it. As for the method of tackling a similar job, in my reply to Mr. Haney, I have indicated that I would attempt still higher mounting heights, if possible, which would result naturally in still wider spacing.

As for the Mall towers, here the over-all lighting design was deliberately broken to dramatize the Mall area and have it stand as the focal point of the Central Terminal Plaza. In addition, a much sharper beam than was obtained from the 70-foot mounting heights was needed for the kind of effect being sought. It is true that at the lower mounting heights used in the Mall area, the imperfections of improved-color mercury vapor lamps are apparent. It is my feeling that mercury vapor lamps, which combine the advantages of simple handling, manageable beams, high intensity and long life, are the best solution for large area lighting out-of-doors. The color problem, although different from that of fluorescent, will, I believe, be solved more and more efficiently in time.

After the system was all turned on, no more than minor adjustments were necessary. The original mounting angle for each unit had been carefully followed during installation, as per charts issued for this purpose. Once the reflector situation was corrected, it was not necessary to change any of the unit mountings.

The high-ranger equipment Mr. Palmer asks about, refers to trucks equipped with self-elevating ladders designed to stop at any given height. At the top of the ladder, a maintenance man sits in a bucket from which he can work or transfer to a maintenance platform, if this is provided. In the case of the New York International Airport, high-ranger equipment which can reach to heights of 90 feet is being used for maintenance.

Applications for Retired Membership

By action of the membership of I.E.S., the new retired membership classifications became effective in the fiscal year beginning October 1956. Privileges in these new grades, earned by long membership in the Society, include reduced annual dues ($5.00) with the continued receipt of all Society mailings including ILLUMINATING ENGINEERING. Such members will be designated as Member, Retired; Associate Member, Retired.

Those who are interested and qualified (at least thirty years of membership and 65 years of age) should address a letter to the General Secretary at Society Headquarters, stating that they have retired from regular occupation in business or profession.

Uses of New Mercury Lamps

(Discussion of paper by D. R. Phillips and E. C. Martt, published October 1957 issue of ILLUMINATING ENGINEERING)

G. A. FREEMAN:* There are several disadvantages in a single bulb tubular mercury lamp, such as the 1500-watt lamp described here, which are taken care of in lamps of the more conventional double bulb design.

The authors have indicated that special fixtures are needed to meet special heat requirements of the lamp to take care of the ultraviolet hazard and to control the light of an elongated arc. There is no possibility of color correction without an outer bulb on the lamp. The problem of periodic cleaning fixtures and lamps requires more instruction in order to avoid damage to the quartz bulb.

The standard 1000-watt AH15 mercury lamp is also rated at 1500 watts with a life conservatively rated at 2000 hours and light output of 80,000 lumens. It should be more suitable for general lighting and floodlighting in all applications except where the ultraviolet output or a narrow vertical beam is desired. The AH15 has an outer bulb which takes care of the ultraviolet hazard and is easy to clean. Its more compact six-inch arc makes it suitable for lower cost more conventional fixtures. Several color corrected types of this basic lamp are available. The dual rating also permits installations where two light levels can be provided, the higher level for rush hours, the lower level for off hours.

R. R. WYLIE:** The author's careful development of instructions for using this lamp should be helpful to fixture designers. Only three questions remain unanswered in the first part of their paper. (1) What are the ballast losses expected with this lamp? (2) What is the electrode construction and operating pressure? (3) Of what economic value in a day of color-improved mercury lighting is this raw, unmodified mercury source? The last question is not posed facetiously, for we fail to see the advantage, as cited, of seeing our friends off or greeting arrivals at Idlewild Airport in the sickly pallor of unmodified mercury vapor lighting.

We are particularly interested in the claims made for the efficiency of the 400-watt reflector type lamps (KC-H1 and/or KS-H1-R52 or R57) versus the conventional mercury shapes (J-H1 or S-H1-BT-37). While we do not doubt the accuracy of the measurements made in the preparation of Table IV, we do feel that the basis of comparison for publication purposes is not a particularly fair one. Have the authors based their photometric analysis on porcelain-enamel equipment particularly designed for mercury vapor lamps? What diameters of porcelain-enamel equipment were analyzed? It has been our experience in optical design that the interception factor of a source may have a very important bearing on the efficiency of the equipment. We believe the authors will agree that differences will occur between a correctly positioned lamp and reflector when the gamut of size of light source runs from approximately ¾-inch diameter to 4⅝-inch diameter to 6½-inch to 7⅛-inch. It should also be pointed out that the shape and total overall length of bulbs will cause significant change. We question seriously if the dirt and dust maintenance of the reflector bulb shape lamps is better than the conventional bulb shape lamp under identical operating and fixture conditions. We would suggest that data be made available on these bases for both porcelain and aluminum reflectors of comparable design.

Undeniably the brightness readings shown in Fig. 8 are significant and great visual comfort can be obtained with aluminum or glass, but the comparison, to be truly significant, should have been fairly given on comparable equipment. A serious review of the foregoing factors will undoubtedly change the economic study alluded to — a more even balance between the various sources will result.

R. E. FAUCETT:* The authors have covered many facets of mercury lamp and luminaire design with applications. However, I am in a position to comment only upon the section dealing with floodlighting luminaire design, and I have limited the remarks to this phase.

A parabolic reflector (similar to their Fig. 4D) was designed for building floodlighting applications. It is recognized that this design is a comparatively simple one; however, I would like to point out that the resulting distribution in a plane perpendicular to the lamp is not an ideal one. The distribution is one in which the maximum candlepower occurs in the geometric center of the beam. This means that 50 per cent of the light is above the center and is usually wasted by aiming the maximum candlepower near the top of the facade being illuminated. This is generally done in an effort to produce the desired uniformity. More desirably, the maximum beam candlepower should occur at the top of the beam with an immediate reduction to nil at higher angles. The candlepower at angles below the maximum should then gradually diminish to zero at 90 degrees from maximum. This would provide a distribution which would produce better uniformity when aimed at grazing angles because the relative values of intensity would more nearly offset the effect of greater projection distances and incident angles (θ) which occur as the area to be lighted becomes taller. There could be, theoretically, an ideal candlepower distribution developed for any given location of a floodlight to illuminate any facade to perfect uniformity. Any such specification would be based upon the illumination levels required, projection distances and the incident angles.

The ends of the authors' hand-made prototype luminaire were angled out so as to help achieve the desirably large horizontal beam spread. This is, of course, a simple thing to accomplish in design but it is believed to be a relatively ineffective method of achieving the end result in shallow units employing long sources. Also, the magnitude of the candlepower emitted from lamps in a direction approaching parallelism is relatively small. Whether or not it is beneficial to angle out the ends of a luminaire of this type will be dependent upon the individual physical and optical characteristics of the particular design under study. It is suggested to potential luminaire designers that the use of

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**Sylvania Electric Products Inc., Salem, Mass.

*General Electric Co., Outdoor Lighting Division, Hendersonville, N. C.

prismatic glass may be a more efficient means of spreading the available light. Of course, there is no reason why both techniques could not be incorporated into the same design.

It has been stated by the authors that the candlepower near the center of the beam is of less magnitude than at 30 degrees from nadir. It is not obvious to this discussor why this should be so in the design shown in their Fig. 4D. An explanation of the optics involved would be helpful.

Potential users of this, or any other floodlight, should be cautioned to always consult the manufacturer before aiming the luminaire above the horizontal. If the unit is aimed upward special drainage and/or sealing features must be provided to assure satisfactory operation.

When installing the H1500-A23 lamp in its presently designed sockets it has been found that great care must be exercised to prevent certain mechanical failures. The ceramic cap at the point which secures the spade shank has sometimes fractured. Occasionally the spade shank becomes twisted or bent. This occurs because of the present design of the two mating elements: lamp terminal and socket. At present, in order to install or remove lamps it is necessary that the lamp be twisted into or out of the socket. This twist-lock action of the socket is so strong that considerable force must be applied to the lamp in order for the spades to become properly seated in the electrical contact.

Fortunately, more lamps fail mechanically upon removal than during installation. This is apparently due to the oxidizing effect with resultant "semi-welds" produced by heat during operation. The force required to overcome these "semi-welds" in addition to the already high force required to overcome the contact springs may result in mechanical failure of the lamp base construction.

It is suggested that the mortality rate due to mechanical failures could be reduced by increasing the strength of the spade shank with its supports or perhaps, by designing a socket incorporating a cam-action clamp not requiring the lamp itself to be twisted.

When designing a luminaire to employ a long mercury arc lamp to be operated in a horizontal position it should be remembered that the arc has a tendency to bow up inside the envelope due to convection currents. This can have a very pronounced effect on the resulting photometric performance including beam spreads, candlepower, and efficiencies. This may be corrected by compensation in the design of the reflector and/or cover glass, or by use of a magnet.

The application of the newly developed H1500-A23 lamp in the specially designed Idlewild floodlight has proved to be an excellent and very versatile one. This is evidenced by the fact that it is relatively easy to achieve widely varying beam spreads and maximum beam candlepowers merely by etching one of the five reflectors used in the unit. The resultant photometric values depend upon the degree of etch produced.

I wish to take this opportunity to express my sincere appreciation to Mr. George Johnston, Floodlight Design Engineer, who assisted me in the preparation of this discussion by consultation and review of the rough draft.

D. R. PHILLIPS and E. C. MARTT:* The discussers have brought up many interesting points which add to the value of the paper. To answer specific questions on the H1500-A23 lamp and ballast — first, the lamp operates at about 3 atmospheres pressure with a voltage range of 400 volts to 450 volts (425 volts center). The warm-up time in a suitable fixture is about eight minutes, and the time for a lamp to restrike on hot restart is approximately four minutes, plus an additional four minutes for warm-up. The ballast losses for this lamp will vary considerably depending upon the type of ballast used and the purpose for which it is made. The present ballast, which will start lamps down to −10 F has about ten per cent loss.

Mr. Freeman has proposed the use of the 1000-watt A15 lamp at 1500 watts for the same applications as for the H1500-A23. This proposal has serious obstacles, although at first glance, it may seem to have the advantages that he outlines. In the first place, it is stated that the H1000-A15 lamp operating at 1500 watts has a rated life of 2000 hours rather than the normal 6000-7000 hour life for most mercury lamps. We believe that a 2000-hour rating on such a lamp is not practical for most applications, since one of the great advantages of mercury lamps over filament lamps is their long life. If lamps are mounted, for example, on 75-foot towers, the inconvenience and expense of changing lamps at 2000-hour intervals would be considerable. Furthermore, the short life rating indicates, as would be expected, that the quartz is highly overloaded and that resulting poorer lumen maintenance would make such operation even less desirable. Because of this overloaded condition, it is very likely that base temperatures for 1500-watt operation of the A15 would be excessive. A further point to consider is that color improvement would not be as good with 1500-watt operation as with 1000 watts, since the phosphors would operate at temperatures well beyond their peak efficiency and, therefore, with reduced effectiveness. This is particularly true with the newer white phosphors.

Mr. Wylie questions the listing of a new lamp which does not have color improvement in its light. While there is no doubt that the trend has been towards color improved mercury light sources, the demand for the regular lamps has remained strong. The authors do not feel that there has been any indication that regular mercury lamps are no longer considered for new lighting installations. Certainly at the New York International Airport the choice of light source was determined by the color rendition requirements at the airport. Mr. Wylie asks if the photometric efficiencies shown in Table IV were for tests of porcelain enamel reflectors particularly designed for mercury lamps. Many manufacturers list the same porcelain reflector for different types of lamps because reflector contour has little effect upon light control with this type of reflector surface. The tests shown in Table IV were of a twenty-inch diameter porcelain enamel unit. Mr. Wylie's questions concerning the interception factor of the source are answered in the text of the paper. In regard to the maintenance characteristics of lamps having different bulb shapes, we would agree with Mr. Wylie that the bulb contour should have little effect on maintenance, provided the discussion is limited to clear bulbs. In this paper the comparison was made between clear, silver, and phosphor-coated bulbs. The silver and phosphor-coated bulbs change the light distribution of the arc tube. Thus, with less light transmitted through the sides of this type of lamp, dirt collection on the sides of the bulb will have less effect on light output than in conventional lamps. Concerning the comfort of porcelain and aluminum reflectors, the comparison was made between conventional types of equipment. We do not understand what Mr. Wylie has in mind when he states that the comparison should be made on comparable equipment.

Mr. Faucett's comments concerning reflector design are

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very much appreciated. It was not, of course, the purpose of this paper to discuss all the aspects of luminaire design. The luminaires that were made were "exploratory" units to obtain some idea of the design possibilities for the new 1500-watt A23 mercury lamp. It was pointed out in the paper that although the floodlighting reflector was experimental and thus subject to more variation than a production model, the results were quite useful in showing that a suitable floodlighting reflector could be designed. Concerning the batwing distribution obtained in the plane parallel to the lamps axis, it was not stated that the candle power at the center of the beam was less than that at 30 degrees from nadir. There were fluctuations in the center of the beam but the statement was made that the average candle power over the central three-degree cone was 140,000. Since this was a laboratory model the control of the parabola was not as accurate as desired, and thus the candle power in the center of the beam was not as high as it should have been. With proper control of the parabolic section of the reflector, the maximum candle power would certainly be higher than 180,000. Mr. Faucett may have based his comments concerning the mechanical strength of the lamp base on some of the first lamps that were manufactured. This is not felt to be a problem with present lamp design.

How Well Can Searchlights Search?

On the facing page is published another of the Society's technical committee reports, this one covering the specialized, though highly important, field of searchlights. As will be noted from the foreword, and the objective, its development sprang from a government and industry need for authoritative guidance for the proper testing of searchlight and projection equipment.

Is this important to your particular field of lighting? Perhaps not. To the hundreds of engineers engaged in this field, however, it is an important documentation of procedure — authoritative — prepared by specialists.

To other lighting personnel, not close to the searchlight field, or indeed, far from it — the significance of the report has been outlined as follows:

Every minute two powerful pencils of light sweep out to sea from the top of the Empire State Building with an estimated visibility of 200 miles in clear weather. Every night aircraft pilots are guided safely to their destinations because of rotating aircraft beacon searchlights forming a continuous line of markers outlining the highways in the sky until the final beacon points the way to the homeport and safe landing. A searchlight on the pilot house picks up the struggling survivors of a marine disaster or guides the pilot to safe docking at the end of his journey. Day after day each community lies in security from the attacks of criminals housed in prisons because of the guarding light of searchlights.

Obviously, these searchlights must be good!

But how good? And how shall we measure how good a searchlight is? These are proper questions for I.E.S. The answers are not easy.

To get light for great distances through the dust and dirt and mists of the atmosphere, it must be concentrated in a pencil of light. This narrow beam is different from the pattern of a floodlight that lights up a broad area in its immediate vicinity. It is comparatively easy to measure widespread distributions of light from floodlights and general lighting units. But it is a different matter to measure accurately the candlepower distribution of a narrow pencil of light in order to know how far the beam will carry out its mission.

In searchlight beams, the rays of light are almost parallel — almost, but not quite. The photometrist must determine, from the analysis of the reflector contour and from exploration of the beam, how far away from the searchlight he must go to be sure that the true form of the beam has been established. In order to find the center from which they proceed, as though they were coming from a point light source (and therefore the inverse square law applies) one must know the point at which they converge after leaving the reflecting surface. Then one must measure the beam anywhere from 25 feet to several hundred feet away from the searchlight itself and at tiny angles of one-tenth degree throughout its width. Such extremes indeed tax the skill and ingenuity of photometrists.

Facilities for searchlight testing are unique. The long "test throws" between searchlight and cell can often be achieved only on open ranges. That introduces a new condition — atmospheric absorption and dispersion, of which measurements must be made. Sometimes these measurements must be made several times during a test, to make sure that changing atmospheric conditions do not destroy the test accuracy. Furthermore, the only practical procedure is sometimes to make these open-range tests in the daytime, with the daylight factored out. You may ask: Is that really possible? Yes, it's possible — but it isn't easy!

All of these processes have been worked out in a standard procedure by the combined efforts of the Searchlight Committee and the Testing Procedures Committee. It is presented herewith as the I.E.S. Guide for Photometric Testing of Searchlights. It represents the combined experience of the military, the manufacturing groups and the Bureau of Standards over the year, especially stimulated by the last two World Wars.

I.E.S. Guide for

Photometric Testing Of Searchlights

Prepared by the Subcommittee on Guide for Photometry of Searchlights of the Committee on Testing Procedures for Illumination Characteristics and the Subcommittee on Testing Procedures of the Searchlight Committee of the Illuminating Engineering Society

FOREWORD

The following guide was started in 1951 by the Subcommittee on Guide for Photometry of Searchlights of the Committee on Testing Procedures for Illumination Characteristics. Mr. T. H. Projector of the National Bureau of Standards was instrumental in developing the first drafts. Later the Searchlight Committee was formed and actively participated in aiding the above Subcommittee in developing the final draft through its Subcommittee on Testing Procedures.

SUBCOMMITTEE ON GUIDE FOR PHOTOMETRY OF SEARCHLIGHTS
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1. Introduction

1.1—*Objectives* — To provide a guide that will promote uniformity in the determination and reporting of the candlepower distribution characteristics of searchlights and projection equipment of similar nature having a beam spread (divergence) of less than ten degrees in any cross section. (See Figure 5.)

1.2—*Scope* — **(a)** Except where specifically covered by other I.E.S. publications this guide will apply to lighting equipment having a total beam spread (divergence) of less than ten degrees. It will include equipments in which the light is controlled by reflectors, lenses or their combinations. It will apply to projectors having any light source such as incandescent filament lamps, mercury vapor discharge lamps, open arcs or other sources of high brilliancy which are capable of producing the specified beam spread.

(b) For further information reference should be made to the "I.E.S. General Guide to Photometry."[1]

2. General Procedure

In general, testing of this equipment should consist of the following:

(1) Determination, setting up and use of proper range facilities.
(2) Selection of testing apparatus.
(3) Selection and preparation of the equipment to be tested.
(4) Procedure for taking the measurements.
(5) Computation of test results.
(6) Reporting of data.

3. Range Requirements

3.1—*Range Length* — **(a)** There is a critical point on the axis of a searchlight beam beyond which the inverse square law is applicable in photometric calculations. The distance from the searchlight to this point is called the "minimum inverse square distance" and photometric measurements should be made at or beyond this distance.

(b) To determine the minimum inverse square distance for a searchlight, the distance must be determined for each small area on the searchlight optic,* and the maximum distance thus obtained is taken as the required minimum inverse square distance for the searchlight as a whole. The following general formula may be used: (See Fig. 1a.)

$$L_0 = \frac{ad}{6s} \qquad (1)$$

where L_0 is the minimum inverse square distance for the small area of the optic under consideration. (In feet.)
a is the distance from the small area to the axis of the searchlight. (In inches.)
d is the distance from the light source to the small area. (In inches.)
s is the smallest projected dimension of the light source as viewed from the small area. (In inches.) For example, s is the diameter of one coil of a multi-coil filament lamp, etc.

It is usually unnecessary to compute L_0 for more than one area of the optic, since the area that will maximize L_0 can often be determined by inspection.

(c) Light sources may sometimes be treated as approximately disc-shaped or spherical, in which event one of the two following formulas may be useful:

Approved by the Council of the Illuminating Engineering Society, April 1957. A Transaction of I.E.S.

*A reflective or refractive element or combination of elements which collimates the emergent light beam of a searchlight.

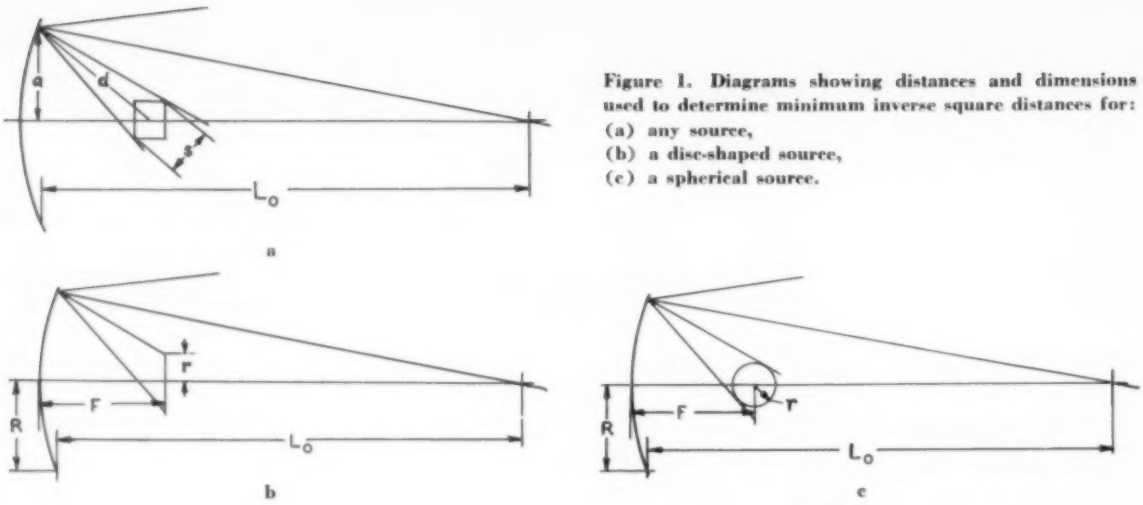

Figure 1. Diagrams showing distances and dimensions used to determine minimum inverse square distances for:
(a) any source,
(b) a disc-shaped source,
(c) a spherical source.

For disc sources: (See Fig. 1b.)

$$L_o = \frac{R\left(F + \frac{R^2}{4F}\right)^2}{12r\left(F - \frac{R^2}{4F}\right)} \qquad (2)$$

For spherical sources: (See Fig. 1c.)

$$L_o = \frac{R}{12r}\left(F + \frac{R^2}{4F}\right) \qquad (3)$$

In the above equations, L_o is in feet, all other dimensions in inches.

L_o is the required minimum inverse square distance, measured from the aperture plane of the optic.

R is the radius of the aperture of the optic.

F is the focal length.

r is the radius of the light source.

(d) The foregoing treatment of the determination of minimum inverse square distance was based on ideal sources and axial measurements, and should be considered approximate. In practice, a range two or three times the minimum computed length is adequate. If it is impractical to make measurements on a range of this length, shorter ranges may be used, even less than the minimum inverse square distance, provided that the searchlight is focused for maximum candlepower at the range distance. (See Section 5.3.) While a full length range is preferable for highest accuracy, the error can be kept to a minmum by this method. For additional information consult references 2, 3, and 15.

(e) Two sample calculations of minimum inverse square distance are shown below:

Example 1: It is proposed to determine the minimum range length for photometric measurements on a carbon arc searchlight with high-intensity carbons 11 mm in diameter, and a reflector 19 inches in diameter with a 6-inch focal length. Experience indicates that the "gas ball" of a high intensity carbon arc may be considered as approximately disc shaped. Examination of a brightness distribution across the end of the carbon indicates that the brightness is approximately uniform across about 7 mm (0.28"). Using equation (2) for disc sources, we obtain:

$$L_o = \frac{9.5\left(6 + \frac{9.5^2}{4(6)}\right)^2}{12(.14)\left(6 - \frac{9.5^2}{4(6)}\right)} = 241 \text{ Feet.}$$

In accordance with (d) above, a range length of 500 feet or more would be adequate.

Example 2: The searchlight has a xenon compact arc approximating a sphere of about 5 mm in diameter (0.20 inch) with uniform brightness and a reflector 12 inches in diameter with a focal length of 5 inches. Using equation (3) for spherical sources, we obtain:

$$L_o = \frac{6}{12(.10)}\left(5 + \frac{6^2}{4(5)}\right) = 34 \text{ Feet.}$$

In accordance with (d), above, a range length of about 75 feet or more will be adequate.

3.2—*Range Location*—(a) A range which is totally enclosed is preferable to one which is open because stray light and the atmospheric absorption can more easily be kept to a minimum.

(b) Due to the great distances at which searchlights must be photometered indoor ranges are frequently impractical. Outdoor ranges suitable for daytime measurements require particular attention to methods of reducing stray light, minimizing atmospheric disturbances and correcting for atmospheric transmittance. Range sites should be selected where the terrain is flat and should not be located where atmospheric disturbances occur regularly or where dust and/or moisture are prevalent. Care should be taken to insure that the photometer receiving surface is exposed to the entire searchlight aperture, and that suitable diaphragms be provided to exclude and/or minimize stray light. For example, in the northern hemisphere ranges should lie in the north-south line with the goniometer in an enclosure at the south end. In this way, the shaded north side of the goniometer enclosure and of any intervening baffles will face the photometer.

3.3—*Range Correction*[4]

3.3.1—*Stray Light*—**(a)** There is the possibility, particularly on open ranges, that stray light is finding its way through the baffling system into the photometer. The amount of stray light should be determined and should be subtracted from all readings.

(b) Since outdoor lighting condi-

tions vary, periodic checks should be made during test as to variations in stray light conditions and test readings corrected accordingly.

3.3.2—*Atmospheric Transmittance*[7]

3.3.2.1—*General*—The atmosphere of photometric ranges absorbs and scatters light sometimes to an extent which may significantly reduce the illumination on the photometer. It is, therefore, necessary to measure the transmittance of the range and to correct the photometric readings accordingly. Atmospheric transmittance conditions may vary, and periodic checks should be made and test readings corrected accordingly.

3.3.2.2—*Methods for Determining*—Three basic methods have been satisfactorily used and are recommended. They are as follows:

(1) The Reference Projector
(2) The Two-Station Method
(3) The Target Brightness Method

3.3.2.2.1—*The Reference Projector Method*—**(a)** This method utilizes essentially a projector whose minimum inverse square distance is short enough to permit calibration in an indoor range and yet has sufficient light intensity to permit a satisfactory reading on the photometer at the end of the test range. The reference projector is mounted in place of or in close proximity to the test unit and the beam projected over the entire length of the range as used for the test unit. It is, therefore, possible to use this method for absolute calibration of the photometer and range. If atmospheric correction only is required, relative readings (candlepower for 100 per cent transmittance and candlepower for the test condition) only are required.

(b) The reference projector should employ a stable light source, and should be accurately aligned with the receptor. Low voltage, high wattage incandescent filament lamps can be used and operated below their rated voltage to insure stability. To assure consistent results the projector should have a lightly etched cover glass to smooth out the filament images and give a uniform candlepower distribution over a relatively wide angle from the beam center.[5,20]

3.3.2.2.2—*The Two-Station Method*[6]—**(a)** This method consists essentially of measuring the apparent candlepower of a reference searchlight at two different distances along the range to determine the loss in candlepower which represents the loss in transmission. Under this method, calibration is not necessary for either the reference projector or the photometer. It is necessary that both measuring points be located beyond the minimum inverse square distance and that the equipment be accurately aligned. The searchlight should employ a stable light source and should be accurately aligned with the receptor. Low voltage, high wattage incandescent filament lamps can be used and operated below their rated voltage to insure stability. To assure consistent results the projector should have a lightly etched cover glass to smooth out the filament images and give a uniform distribution over a relatively wide angle from the beam center. If two different receptors are used at the two measuring points they must be calibrated relative to each other.

(b) The computation of the transmittance of the range with the two-station method is based on Allard's law:

$$E = \frac{I}{D^2} T^D$$

where E is the illumination at a distance D from a source of intensity I when T is the transmittance per unit distance. The formula to be used in computation is:

$$T_{D_1} = \left(\frac{E_1 {D_1}^2}{E_2 {D_2}^2} \right)^{D_1/(D_1 - D_2)}$$

where T_{D_1} is the transmittance of the range
D_1 is the length of the range
D_2 is the distance of the second station
E_1 is the measured illumination at D_1
E_2 is the measured illumination at D_2

(c) A sample computation of range transmittance is as follows: Assume a test range 1340 feet long, a second station at 150 feet, ascertained to be beyond the minimum inverse square distance. Assume further that at a given time, E_2 is 95 times as great as E_1.

$$T_{D_1} = \left(\frac{1 \times 1340^2}{87 \times 150^2} \right)^{1340/(1340-150)} = .91$$

or the transmittance of the range is 91 per cent.

It will be found convenient to prepare a table or a graph showing the relation between the ratio E_1/E_2 and the range transmittance.

3.3.2.2.3—*The Target Brightness Method*[7,21]—Another method of measuring transmission is based on the use of a telephotometer to measure the photometric brightness of a target surface over the length of the range. The target must be of sufficient size and of uniform brightness. The telephotometer may be adapted from a conventional photometer by the use of a telephoto lens of suitable focal length. The brightness of the target must be measured at close range. The ratio of the apparent brightness as measured on the range to the true brightness as measured close by is then the transmittance. This method is not adapted to use in daytime photometry.

4. Testing Apparatus

4.1—***Goniometer***[8,9,10,11]—**(a)** The basic requirements of the goniometer are to provide suitable means for:

(1) mounting the projector
(2) rotating the projector through the required angular traverses
(3) measuring the angles within the traverses.

(b) Since the searchlights covered by this guide will often have extremely narrow beam spreads (divergence) and may also be unusually heavy, the mechanical requirements of the goniometer are more severe than for other types of photometric test equipment.

(c) Suitable rigidity and freedom from backlash must be provided for the correct measurement of the angles especially when an elevation traverse passes through a balance point or there is appreciable off-balance loading. Goniometers should have provision for accurate angular settings of the order of 0.1 degree. In special cases higher orders of accuracy may be required.

(d) The mounting of the searchlight should also be rigid and have provision for the convenient adjustment of the searchlight within the goniometer. A heavy table with T-shaped slots running perpendicular to each other has been successfully used (see Fig. 2).

(e) Searchlights are generally tested in such a manner that the polar axis of angular measurements is horizontal. For special applications it is advisable to have the goniometer so constructed that the polar axis of angular measure-

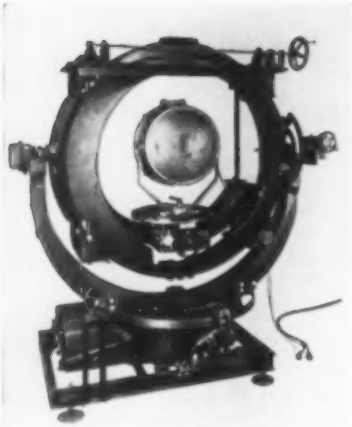

Figure 2. A Goniometer with searchlight in place.

ments can be either vertical or horizontal (see Fig. 2). The polar axis of angular measurements will be horizontal (see Fig. 3) when the horizontal rotation of the goniometer is always about a fixed vertical axis. For this condition the revolving table must be outside of the frame within which the projector is mounted. The polar axis of angular measurements will be vertical (see Fig. 4) when the "horizontal" rotation is always about the vertical axis of the projector itself. For this condition the revolving table must be within the frame which provides the projector mounting and the vertical movement.[11]

(f) When the searchlight is of unusual size and weight it may be necessary to utilize its own mounting and goniometric facilities for the photometric work, or to hold the searchlight fixed and traverse the beam by moving the photometric receptor.

4.2—*Photometer*[4,15] — **(a)** The photometer may be either of the visual or physical type and it should be calibrated for the conditions under which it will be used in testing.

(b) The use of a filter to correct the spectral response of the cell to the spectral sensitivity curve of the average eye is essential. If the searchlight beam is highly chromatic, the accuracy available with commercial spectrally-corrected photocells may be inadequate. In this case it may be necessary to use correction filters specially designed for particular photocells. However, considerable improvement in accuracy can sometimes be obtained with commercial photocells, at less trouble and expense than by designing special filters, by spectrally matching the calibrating light source with the searchlight beam.

(c) Variations in ambient temperature may adversely affect photometric measurements made with physical photometers, particularly in outdoor ranges where the photometer is unprotected from such variations. The use of insulated and thermostatically controlled housings is recommended.

4.3—*Instruments* — **(a)** Instruments used in measuring and control circuits should be selected to provide accuracy and readability adequate for the intended purpose. In particular, the light output of incandescent filament lamps is critically dependent on voltage and current and measurements of these parameters must be made with considerably greater accuracy than the basic photometric accuracy required. For precise photometry it is desirable to use a potentiometer, although for less precise work, instruments with an accuracy of one-fourth per cent may be adequate. Generally, incandescent filament lamps in test equipment or in calibration equipment, especially high-current lamps, should be set by current rather than voltage in order to eliminate contact voltage drops and other circuit resistances as sources of error.

(b) Mercury vapor lamps should be operated at rated watts and open arcs at manufacturers rating. The instruments should have an accuracy of $\pm\frac{1}{4}$ of 1 per cent of full scale deflection and be selected to give a large scale deflection for the conditions under which they are used.

5. Selection and Preparation of the Equipment for Test

5.1—*Selection* — The searchlight to be tested should be a representative sample of the manufacturer's regular product. It should be checked to insure that it is in good optical, mechanical and electrical condition.

5.2—*Mounting* — The searchlight should be mounted on the goniometer with the intersection of its axes of rotation close to the intersection of the axes of rotation of the goniometer. In the event that the projector does not have rotation gear then it should be mounted so that the light source is close to the intersection of the axes of rotation of the goniometer.[5]

5.3—*Focusing*

5.3.1—*General*—(a) Projectors should be focused to give the narrowest and most sharply defined beam pattern at approximately the same distance as that at which the test is to be made.

(b) Some of the above methods of focusing determine best focus for the distance at which the determination is made, while two of them focus for infinity. If the range distance is not appreciably greater than the minimum inverse square distance then one of the former group should be used. One of the infinity-focus methods may be used

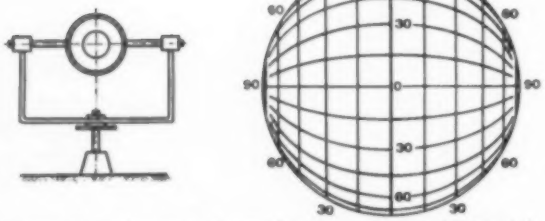

Figure 3. Polar axis of angular measurement horizontal.

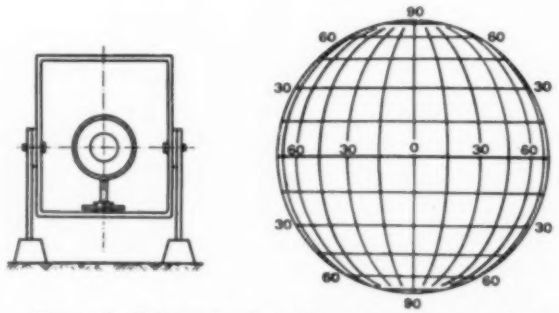

Figure 4. Polar axis of angular measurement vertical.

to readjust the searchlight after photometry. The two methods that focus for infinity are the Perforated Disc and Screen and the Projected Shadow methods.

5.3.2—*Visual Alignment* — Prior to focusing it is necessary to check or adjust the alignment of the light source on the optical axis of the searchlight. One method for determining the axis of searchlights and locating the light source upon it is to stretch a pair of strings across the aperture of the reflector so that their intersection lies at the center of the aperture. Looking through the lamp bulb towards the reflector there will appear in order the lamp filament, the crossed strings, an image of the crossed strings, and an image of the filament. (The lamp may be turned on at low voltage to facilitate observation.) If the center of the filament and the intersection of the strings and their images all lie in the same straight line then the lamp is on the axis. Any departure of the geometric axis of the aperture from the optical axis of the reflector will result in a proportional displacement of the images of the strings from the strings.

5.3.3—*Visual Adjustment* — In this method the beam is projected upon a target normal to the beam axis and a distance from the projector which is approximately equal to the test distance. The target should be large enough to include the major portion of the beam and the projector focused until the narrowest and most sharply defined beam pattern is obtained. This method is satisfactory for indoor ranges and relatively short outdoor ranges when the focusing can be done at night.

5.3.4—*Adjustment for Optic Flash* — If a uniform source is placed at the focus of a perfect optic and this optic is observed from a point on the axis at or beyond the minimum inverse square distance it appears to be fully flashed (bright all over) to a brightness equal to that of the source. It is, therefore, possible to determine the correct focus of the projector for a given distance by observing the amount of optic flash. It is necessary that the optic be observed from a point along the beam axis and at the distance at which the test is made. In practice optics are imperfect and light sources are more or less non-uniform so that it is often difficult to obtain uniform flashing of the optic aperture. Furthermore, some obstruction is caused by the light source mounting. If the light source is extremely small in relation to the optic, complete flashing is particularly difficult to obtain. The optic may be viewed through a telescope. In practice it may be found more desirable to use this method only as a check for both alignment and focus.

5.3.5—*Perforated Disc and Screen Focusing*—**(a)** Essentially this method takes a number of small portions of the beam at predetermined locations and adjusts the focusing mechanism until these miniature beams are parallel to each other and to the optic axis. Any number of small beam portions may be taken but, in practice, the number should be relatively few.

(b) An opaque shield of a size to cover the entire beam is mounted at the opening of the projector in such a manner that it is adjustable with respect to the projector. Five holes (approx. $\frac{1}{8}$-inch diameter) are drilled in this shield, spaced in such a manner that one will be on the optic axis and the other four located 90 degrees apart on a radius which is equal to two-thirds the radius of the reflector. At a distance approximately 5 to 20 times the reflector opening, mount a movable screen on which are located five points which correspond exactly to the five holes in the shield. The center hole is located on the optical axis and the face of the screen is perpendicular to this axis when the projector is leveled so that this axis is horizontal.

(c) The light source will produce five sharp images on the screen. The center hole will produce two images, if the optic is a reflector, one by direct light and one by reflected light. The image produced by direct light will be larger and not as well defined as the image produced by reflected light. The focusing mechanism is adjusted until the two images from the center hole in the shield are superimposed upon each other and all images fall upon their respective points on the screen. The degree of coincidence will depend upon the accuracy of the reflector. If an auxiliary reflector is used a secondary set of images will be produced. The main adjustment should be completed as described above with the auxiliary reflector removed from the searchlight. The auxiliary reflector is then installed and adjusted by alignment of the secondary images in the same manner as the primary adjustment was made, without disturbing the primary adjustments. With the auxiliary reflector in place, the images formed by the center hole will be blocked out. The adjustment should be made so as to build up dark areas, *e.g.*, between filament coils of the primary images, with the secondary images.

5.3.6—*Projected Shadow Method*[22] — **(a)** This method is useful when the light source is very small or when a very small light source may be substituted conveniently for the searchlight's source. It is based on the principle that the shadow of an obstruction placed in a perfectly collimated beam exactly corresponds to the cross section of the obstruction. Since a defining condition of best focus of the light source in a searchlight is that the projected beam shall be most nearly collimated, a comparison of the projected shadow of an obstruction in the beam with the obstruction may be used to make the adjustment for best focus. Any of a variety of obstruction masks may be used, as determined by convenience and the optics in the searchlights.

(b) One convenient form for the mask is a hollow square cut from a metal sheet. The diagonal of the outer edge is slightly shorter than the diameter of the optic. The linear dimensions of the inner edge are about two-thirds to three-quarters of the dimensions of the outer edge. An exact outline of the edges of the mask is traced on a screen which is placed about twice the optic diameter distant from the aperture plane of the optic. The mask is placed close to the aperture plane. The planes of the mask and of the screen are made parallel with the aperture plane of the optic. If the searchlight's light source is not small enough to cast a fairly well defined shadow of the mask on the screen, it should be replaced by a smaller source such as an ophthalmic lamp. The light source is then moved in and out along the optic axis until the position is found at which the edges of the projected shadow most nearly lie on the traced outline, thus establishing the position of best focus.

5.3.7—*Formation of Image of Distant Target at Focal Point* — If a small card is held at the focal point of the projector optic an image of a distant illuminated target may be seen upon it; the image will be small and dis-

Candlepower Distributions — Airborne Searchlight

Reflector: Precision, Parabolic, Back-Silvered Glass, 19" Diameter, 6" Focal Length. Lamp: High-Intensity Carbon Arc, 11 mm Carbons, 16° Trim, 70 Volts, 120 Amperes. (Measurements made with plastic dome removed.)

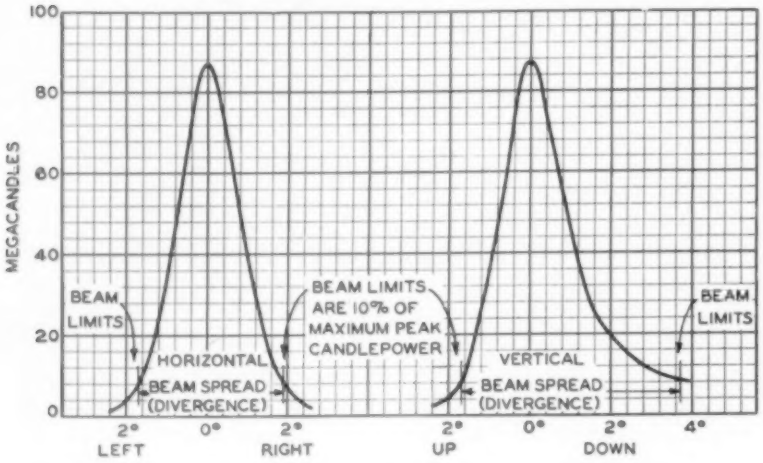

Figure 5. Typical report form showing candlepower distribution.

torted, but if the central portion of the image is as sharply focused as possible, the projector is in focus. Because of the smallness of the image it is desirable to use a fairly large target of high contrast with the background.

5.3.8—*Trial Candlepower Distributions* — Another method of obtaining exact focus and optimum results is to take a series of short candlepower distributions through the approximate axis of the beam, each distribution being taken after a small change in the focal adjustment. The best focus may be determined as that giving the distribution with the maximum candlepower and minimum beam spread. This method is recommended in all cases where it is practical. With multi-coil filament lamps some caution must be used in applying this method of focusing, since the candlepower distribution may contain several more or less well defined peaks from filament images.

5.4—***Cleaning*** — All components of the optical system should be cleaned before testing.

6. Procedure for Making Observations

6.1—*Test Light Sources*

6.1.1—*Incandescent Filament Lamps* — The test lamp should be selected for close conformance to the manufacturer's design dimensions and construction and seasoned in accordance with Appendix A. To insure stable lamp performance, incandescent filament lamps should preferably be operated at a constant current corresponding to approximately 75 per cent of rated lumen output. The results should be corrected for the reduced lumen output by multiplying by the ratio of the rated lumen output to the lumen output at reduced voltage.

6.1.2—*Gaseous Discharge Lamps* — These lamps shall be selected and seasoned in accordance with the manufacturer's recommendations.

6.1.3—*Open Arcs* — These should be operated at manufacturer's ratings.

6.2—*Photometer Calibration*

(a) The photometer may be calibrated against a candlepower standard lamp. It is desirable to calibrate at illumination levels of comparable magnitude to those it is desired to measure. It may be found convenient to use sector discs and/or filters to permit calibration of the photometer at selected levels. Care must be exercised in using filters to avoid errors arising from spectral selectivity.

(b) Where a reference projector is used to measure the atmospheric transmittance of the range, it may be desirable to use the same projector as a calibrator for the photometer, especially where a large number of routine measurements are to be made. This requires an absolute calibration of the reference projector instead of the relative readings only, that are required for the transmittance measurements. Once the reference projector is calibrated, a single reading of its candlepower provides a multiplying factor which in effect calibrates the photometric range as a whole (receptor and transmittance together). Where the difference in order of magnitude between the candlepower of the reference projector and the test projector is large, a sector disc or some other means of equalizing the two illumination levels on the photometer is desirable.

6.3—*Test Data*

(a) In general, testing of searchlights may involve:

(1) maximum candlepower — The point of maximum candlepower is located by scanning the beam pattern.

(2) candlepower traces through the horizontal and vertical axes — A sufficient number of reading must be taken to adequately determine the shape of the horizontal and vertical candlepower traces.

(3) exploration of the complete beam candlepower pattern—The method of taking candlepower readings is to traverse the beam with such spacings as to give approximately 100 reading stations uniformly spaced throughout the beam. The limit of the beam is to be taken as 10 per cent of the highest candlepower value recorded in this prescribed exploration of the beam.* In many cases it will be necessary to determine reference lines by establishing the vertical and horizontal limits of the beam photometrically. The intersecting lines half way between these limits will constitute the reference lines. As a suggested method, the exploration of the horizontal and vertical axes to the limits of the stray light should be made first, followed by horizontal traverses at the various angles to include the limits of the beam.

(b) The lumen output of a projector beam may be measured directly by projecting the beam into a large hemispherical integrating device which has

*This definition of beam spread (divergence) is somewhat arbitrary but has been found to conform fairly well with visual estimate of the widths of searchlight beams. For other types of equipment beam spreads (divergences) are sometimes defined differently.

been made adaptable for such measurements.[13, 15]

(c) In analyzing the performance of light sources in projectors it is often useful to determine the brightness distribution across the source in all directions within the collecting angle of the optic.[4, 14]

7. Computation of Results

(a) The candlepower is computed from the measurement of the illumination on the photometer receptor by means of the following formula:

$$I = (E_1 - E_2)\frac{D^2}{T}$$

Where I = Apparent candlepower of projector.

E_1 = Total illumination.

E_2 = Stray illumination.

D = Test distance.

T = Atmospheric transmittance of the range.

If the light source is operated below rated lumen output the candlepower must be corrected accordingly.

(b) The process of developing useful results may involve the following steps:

(1) Plotting horizontal and vertical candlepower distributions, and from these, if required, deriving isocandle or beam limit curves.

(2) Computing the lumens in each individual test area or rectangle using the proper lumen constants (see the *I.E.S. Lighting Handbook*). In general, care must be exercised in using zonal constants that the angular arguments conform with the goniometer employed in regard to which of the axes is the polar axis (see Par. 4.1 (e) and reference 11 particularly). However, in the case of searchlights as defined in this guide, *i.e.*, projectors with beam spreads (divergences) of less than 10 degrees, the error in the beam flux calculation that will occur if the wrong set of axes is assumed is likely to be well within one per cent and may, in such cases, be ignored.[11, 12, 19]

(3) Summing the lumens of each individual test area, making suitable allowance where a test area lies partially within the beam and partially in the stray light zone.

JOHN DOE COMPANY

Type: John Doe Type XYZ Searchlight
Reflector: 16″ B&L Silvered Glass Mirror (16″ Dia.) Commercial Grade
Aux. Reflector: Silvered Glass Mirror 4.5″ Dia. x 2.75″ Deep
Cover Glass: Clear, Flat, Plain, Heat Tempered

LAMP DATA

Watts: 420 Nominal
Volts: 12 Nominal
Bulb: G-25
Base: Mogul Prefocus
Service: Aircraft Landing
Light Center Length: 1 1/8
Filament Type: C2
Filament Height: 8.7 mm (Actual)
Filament Width: 5.5 mm (Actual)
Lumens: 10,500
Burning Position: Base Down

TEST RESULTS

Max. Candlepower: 2,460,000
Beam Lumens: 2,279
Beam Efficiency: 21.7%
Hor. Beam Spread: 2.37°
Vert. Beam Spread: 3.42°
Beam Focused
Min. Divers.: At 100′

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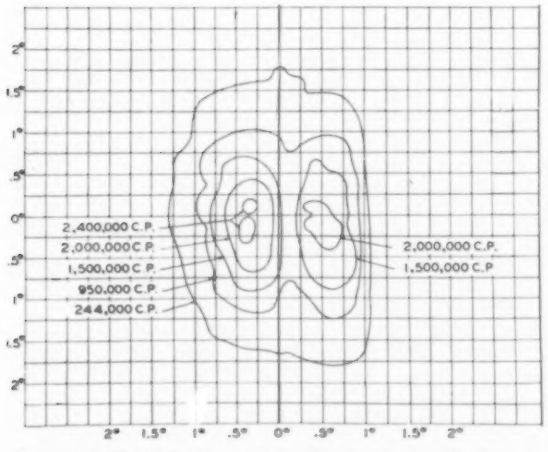

Figure 6. Typical report form showing isocandle lines.

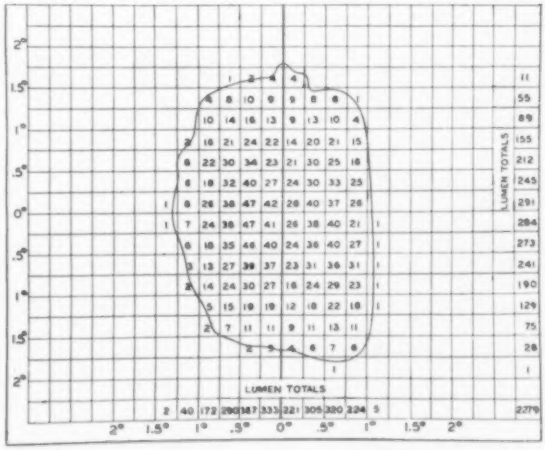

Figure 7. Typical report form showing the lumen distribution in the beam.

(4) Computing beam efficiency of searchlight by dividing beam lumens by total lumen output of test lamp.

8. Reporting of Data

Test results should include the following, as applicable (Figs. 5, 6, and 7 are typical reports):

(1) *Projector description.* The description should include the manufacturer's name, the type and catalog number, the dimensions, shape and size of the optic, the dimensions and optical characteristics of the cover glass, a description of any auxiliary optics, if used, and other essential information including the method of selecting the sample.

(2) *Light source description.* The description should be complete as to type of service and manufacturer's designation and should include the following where applicable: Rating (watts, lumens, volts, or amperes), brightness or brightness distribution, bulb, base, normal burning position, light center length, filament construction, actual light source dimensions, light center position during test.

(3) *Maximum beam candlepower.*

(4) *Beam spread in degrees in both the vertical and horizontal planes.*

(5) *Isocandle or candlepower distribution curves.*

(6) *Lumen distribution in the beam.*

(7) *Beam lumens.*

(8) *Beam efficiency.*

(9) *Test distance.*

(10) *Note of any modifications in the preceding suggested method.*

Appendix A. — Seasoning Schedules for Lamps.

All incandescent filament lamps which are to be photometered should be burned first as indicated in the seasoning schedules below:

LARGE VACUUM LAMPS

Watts	Volts	Filament Construction	Design Life (hours)	Seasoning Min.	Seasoning % Volts
Any	Any	S	0-1399	45	115
		S	1400 and above	60	115
		C	0-500	30	115
		C	501-999	45	115
		C	1000-1999	60	115
		C	2000 and above	60	120

LARGE GAS-FILLED LAMPS

Any	Any	C	0-15	15	100
Any	Any	C	16-99	30	100
Any	Any	C	100-200	45	100
Any	Any	C	300	45	105
Any (Except 1000W-30V)		C	500	45	110
Any	Any	C	750	45	110
0-200	Any	C	800	45	115
201-299	Any	C	800	60	115
300-2000	Any	C	800	90	115
0-74	Any	C	1000	45	115
75-150	32	C	1000	90	115
75-200	100-250	C	1000	45	115
300-2500	Any	C	1000	90	115
Any	Any	C	1350	60	115
Any	Any	C	1500	60	115
Any	Any	C	2000	60	120
900W Proj.	32	C	100	45	100% Amps
Series	(All Types)	C	2000	240	108% Amps
1000	30	C	500	{ 120 { 240	105 100
Series Gr. Replacement (All Types)		C		240	112% Amps

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INSTALLATION AT D. W. G. CIGAR COMPANY, DETROIT, MICHIGAN.

Lighting for Grading and Packaging Cigars

LIGHTING OBJECTIVE: To provide comfortable high level illumination for grading and packaging cigars.

GENERAL INFORMATION: This area, which measures 60 feet by 85 feet with a 14-foot ceiling height, was relighted to reduce the quantity of faulty cigars shipped out of the plant. Along with the relighting, the colors and reflectances of the major room surfaces were changed to:

ceiling	white	80% RF
walls	white	80% RF
columns	white	80% RF
floor	natural hardwood	40% RF
work surfaces	light tan	60% RF

(over)

A.I.A. File No. 31

INSTALLATION: Seventy-one Benjamin Electric Manufacturing Co. 25 per cent upward light, center-shielded industrial type fluorescent luminaires, Catalog No. 96002, are mounted 10 feet above the floor in rows, 9 feet on centers. Each unit is equipped with two 96-inch T-12 standard cool white slimline lamps operated at 425 ma.

The average maintained level of illumination at the task is 90 footeandles. Brightnesses are as follows:

luminaires	
crosswise at 30°	356 fL
at 45°	775 fL
endwise at 30°	597 fL
at 45°	649 fL
ceiling	38 fL
walls	72 fL
columns (near luminaires)	120 fL
floor	31 fL
work surface	53 fL

Lighting designed by Duncan Preston, Engineer, Detroit Edison Co., Detroit, Mich., and Vern Winn, District Representative, Benjamin Electric Manufacturing Co., Dearborn, Mich.

Lighting data submitted by Vern Winn, District Representative, Benjamin Electric Manufacturing Co., Dearborn, Mich., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Views and Opinions

Light, Form and Design

Illuminating Engineering is sometimes referred to as an Art, sometimes as a Science. Actually it is both, a merger of Art and Science, Design and Engineering. The words light, form and design embrace all factors involved in the visual conception of a lighting unit.

The term "Light" as used here, is part of this visual concept. Whether it be a single plane of uniform brightness, or a multiplicity of planes or luminous contours of varying brightnesses, it must be an integral, pre-planned part of the luminaire design. Too often the luminous sections of a fixture's surface pattern are left to chance. In other words, the shielding elements surrounding the light source should create a preconceived plan of either brightness variation to complement the fixture's design, or of brightness uniformity depending on the type of fixture or the effect desired.

Form is the sculptural connotation of the structure surrounding and controlling the light source. It is the first visual impact, the first "seen impression" — the shape totality which creates within a viewer's mind, a reaction of either like or dislike.

Design is the fusion of this form with function. The coordination of light, form, structure and ornament into an overall pattern of visual unity.

Mention of the word "Art" to a group of people brings a varied reaction. Most of them will think of famous paintings. Some will think of Architecture, Sculpture, Music or Literature. Few, if any, will think of the products of industry. It is just in recent years that Art, the unmeasured, and Science, the measured, have achieved a harmonious merger with the result that objects of everyday use can be beautiful as well as useful. The Artist and the Engineer have joined hands, so to speak, to put appearance, style and beauty on an equal basis with utility, function and operation.

In our daily lives we are in constant association with well designed objects: appliances in the home, office equipment, our automobiles, exotic store interiors. Through this daily contact with the work of the country's top designers and architects, we cultivate a sense of taste for good design. We don't put this "taste" away when looking at a technical microscope, a tractor, or an industrial lighting fixture, and consequently this visual reaction is either favorable or unfavorable, pleasant or unpleasant. So, it is important that manufacturers of lighting equipment look at design judiciously and with an open mind. A highly functional parabolic troffer, a precise adjustable spotlight, or a heavy duty industrial fixture cannot be relegated exclusively to engineering, and wise is the manufacturer who realizes this. Design has permeated all fields of creative endeavor. The manufactured article, however technical or however remote it may seem to be from the need for design, can no longer escape its influence.

Quite often I am asked: "Why are incandescent fixtures so far advanced in style over fluorescent fixtures?" To the layman this may appear to be true, if we look at lighting strictly as a style commodity. There is much more to fixture design or appearance engineering than mere superficial styling. Fluorescent equipment is by necessity much larger in scale than the majority of incandescent equipments, and consequently cannot be finished in the same manner. By that I mean that the polished brass lamp housings, chrome-plated ceiling trim etc., so prevalent on incandescent equipment, would be in poor taste on the much larger fluorescent elements. In counter questioning, some of the very people who ask such a question admit that finish, size and decorative perforations were important factors in creating this impression.

Some manufacturers, because of the nature of the lighting market they are trying to reach, stress fixture performance, efficiency, visual comfort or, in short, top optical design. Another group may emphasize styling, design. A third group would be those who stress fixture construction and fixture engineering. The ideal approach for the "furtherance of the Art and Science of Illumination" is to combine all three of these elements. In other words, let's strive for top fixture performance and construction engineering, and make it evident in the external appearance of the fixture. In order to do this, the emitted light must be well modulated and well controlled. The fixture should have a straight-forward elegant form as a result of the careful design of all component parts. And the design should blend all facets of the fixture's surface pattern into a visually compatible whole.

Light means different things to different people, even in the highly specialized field of illuminating engineering. The lighting engineer looks at it one way, the architect another, and the designer has still another viewpoint. All fixtures, regardless of size or shape, whether they be recessed or semi-recessed, surface mounted or suspended, have one or more luminous surfaces. It may be a single plane of uniform brightness as in a recessed glass troffer, or a multiplicity of planes of varying brightnesses, depending upon the type of fixture. The shielding elements and the accompanying structural members form a surface pattern or brightness pattern which if skillfully handled by the designer can create a beautiful lighting element of varied tones of light.

The prime requisite of a good lighting unit is to produce light efficiently, and in such a way that it is comfortable to the user's eyes, and has a pleasing appearance. Fixtures without any regard for a planned brightness pattern with its subtle shades and shadows form mere "blobs" of light. There are a large variety of shapes of plastic enclosing elements available today and there are a number of them with very pleasing contours. However, there seems to be a complete disregard for these contours in the positioning of the lamps. When

A, B, and C illustrate respectively, the basic form, the illuminated form, and the illuminated form with brightness variations designed to emphasize the contours of the fixture. This is further evident in perspective sketch at center of page. Profile view at top illustrates at (1) peaked vee which accents fulcrum of balance and symmetry; (2) and (3) decorative end emboss which emphasizes form and integrates screw heads as part of the design; (straight section of emboss (3) provides horizontal line for product identification). (4) Curved upper contour of enclosure terminating in smaller radius at either side symbolizes reflector contour and is expressive of fixture's function; (5) radius on chassis end profile provides clearance for hinge action of enclosure and with radii on top corners of chassis presents a soft, smooth, appearance and a proportional relationship to the radii on the enclosure.

lighted they become a mass of light with a mass similarity. Through careful and precise relationship between lamp and enclosing element coupled with the desired contour, it is possible to create subtle graduations of tone which emphasize and enhance the shape of the enclosing element.

Even contrast has an important place in fixture design, contrary to some thinking. It is true that large adjacent areas of light and dark are uncomfortable and undesirable and these we want to avoid. But the slim shadow lines of structure become an element of design and at once give definition and direction to the overall appearance. This type of contrast is not objectionable.

Now and then one hears the comment that a lighting installation to be good should be inconspicuous and unnoticeable. One should not be conscious, they say, of where the light is coming from, but merely have a feeling that there is adequate and comfortable illumination. If this be true of lighting, I think it should also be true of the desks in an office or a schoolroom, of the furnishings and decoration of modern store interiors. What a drab world this would be if we tried to make everything inconspicuous. It is my view and opinion that lighting cannot, and should not, be hidden and subjugated to inconspicuity. It is going to be seen, its effects are going to be seen, and these effects should be interesting and devoid of an overall, monotonous flood of light. Through scientific control and planned brightness variations in the fixture itself and in the space between fixtures, we can achieve a degree of psychological comfort which goes beyond the physiological comfort of prescribed glare ratings. A pleasant and comfortable sensory reaction, is the result of a well designed lighting element in a well designed installation.

Light can be compared with and treated as sculpture in many respects. In fact, it is in effect a "fourth dimension" for lighting designers and interior designers to work with. The space between fixtures, the space between the fixture and the ceiling, the space between the fixture and the person viewing it all must be considered as part of the fixture's overall lighting effectiveness. The various elements of an architectural interior, walls, floor, ceiling, doors, windows, partitions, beams, columns, become intercepting planes and solids for this fourth dimension of light. A sculptor thinks of a composition in terms of points, lines and planes, and what is inter-

cepted light, but a composition of points, lines and planes? To quote the famed Japanese sculptor Isamu Noguchi — "If sculpture is the rock, it is also the space between the rock and a man." So it is with light. The space confined, the room interior, becomes part of this composition and in so doing integrates light, color and space. This sculptural integration of light and space is dramatically demonstrated in display and theatrical lighting, used more and more in contemporary home and office lighting.

Closely related to light and homogenous to all fixtures is "form." Simply stated, form is the shape of an object which can be seen and touched, the first visual impression of that object. In a successful lighting fixture design this form can create a visual impact which will be reflected in a striking lighting installation and in a beautiful sales curve for the manufacturer. The fixture designer, much like the sculptor, is dealing with shapes and masses and must correlate these various masses into a pleasing overall total shape. Certain shapes are more satisfactory than others; have more inherent eye appeal; we instinctively like them. In lighting fixture design, we should strive for a form which is dignified and which expresses the technical design of the unit. Its appearance, its form, should grow from this technical design. And conversely, a good appearance can reflect the quality of the engineering behind it. Consequently, throughout the entire process of engineering, esthetic consideration must be kept in mind. The resultant form will be one which is planned; one that shows evidence of care and thoughtfulness in the entire creative process. In certain types of highly technical lighting equipment, such as parabolic troffers and upward component industrial luminaires, a beautiful and precise appearance will add much to the technical merits of the equipment. Just as we can bring out and emphasize the engineering of a fixture through this element of form, so too, can we bring out and emphasize the best qualities of this form through design and ornament.

Design is the magical element that brings about the fusion of form and function. Surface variation, texture, light, line and color create a psychological reaction which can be predetermined by the designer. By that I mean that a feeling of elegance or of strength, or of precision, or of superb engineering can be transmitted to the viewer through the processes of design. There are certain basic design principles which help to bring this about, which are inherent in all good design. In the illustration that accompanies this discussion some of these principles are graphically illustrated. Balance and symmetry, unity and integration, proportion, accent or emphasis, the importance of ornament and brightness pattern, all of these are evident in this one composite illustration.

Ornament is, in my opinion, a psychological necessity. But its chief function should be to emphasize form, rather than to embellish a plain surface. Basically, there are two types of ornament — structural and applied — and it goes without saying that the most successful designs are those in which the ornament is treated as part of, and integrated with the structure.

The desire for beauty is an elemental human urge. Function and usefulness in themselves have not been enough to satisfy the human desire for beauty. Countless products of modern industry and countless creations of the craftsmen of yesteryear bear this out. Take such utilitarian objects as a hand-drill, a lathe chuck, an operating room light, or a hospital bed lamp. Manufacturers of all of these items, scientific though they may be, have gone beyond the considerations of engineering and end use, and have called on the designer.

There is much discussion of what tomorrow's lighting will be like. By studying what has been done in the past, and what is being done today, we can discern certain trends. We can even anticipate how long these trends will continue. However, there is no reason to assume that the lighting of fifteen years from now will look any more like today's lighting, than current practice looks like that of fifteen years ago. One thing is certain: that out of the merger of Art, Science and Industry, will come a new pattern for lighting — a new concept of fixture design.

The rules for visual clarity do not change. It is the unrestricted application of these rules, the freedom of expression afforded the designer which alone can avoid the dry results of the dogmatic. — CARL X. MEYER, *Manager of Design, Day-Brite Lighting, Inc., St. Louis.*

Officers and Committee Lists in April

The revised listing of I.E.S. National and Local Officers and the Standing, General, Task and Technical Committees for the year 1957-1958 will appear in the April issue of ILLUMINATING ENGINEERING.

Here and There With I.E.S. Members

Officers of Sections and Chapters in the East Central Region met at the Holiday Motor Hotel, outside Harrisburg, Pa., November 15, for a joint local activities meeting and Nominating Committee meeting. Chick Shotwell (hand on rail), Regional V-P presided. I.E.S. Executive Secretary A. D. Hinckley (far left) also attended.

Meeting the press, at a press conference at I.E.S. Headquarters, members of the Aviation Lighting Committee reported problems under study on signal and aviation lighting. Left to right are: R. J. Stefany, Secretary, Aviation Lighting Committee; Tom Edwards, Liaison Chairman, IES Aviation Lighting Committee and Society of Automotive Engineers Lighting Committee; Lester C. Simpson, Chairman, Aviation Committee; F. C. Breckenridge, Chairman, Aviation Papers Committee; and Martin A. Warskow, Vice-Chairman, IES Aviation Committee.

Nor sleet, nor snow, nor freezing rain kept the representatives to the Northeastern Regional Nominating Committee from attending the January 14 meeting, at Hartford, Conn. In photo at left, l. to r., H. A. Anderson, Chairman, New York; William P. Carpenter, Secretary, Connecticut; Robert Babcock, Chairman, Connecticut; C. E. Waldron, Northeastern Regional V-P; Walter Ball, Chairman, New England; John Carr, Secretary, New England; J. W. Hamilton, Secretary, New York. In photo at right, C. W. McCormick (seated), I.E.S. Director and past Regional Vice-President, discusses a problem of local interest with Chairman Babcock of the Connecticut Section.

LIGHTING NEWS

Outdoor Clinic Plus — Idlewild Inspection

What may eventually turn out to be the country's most extensive — and most perfectly planned — lighting installation, was inspected by members of the New York Section, January 30. This was the tour taken by some 150 I.E.S. members, of the several buildings so far completed in "Terminal City" — New York International Airport. Construction of the 4900-acre "Gateway to the United States" is scheduled for full completion during 1960. A preview of its magnificent planning and equally magnificent lighting, was afforded the New York Section members who toured the completed buildings and outdoor park, prior to their public opening. The tour was followed by dinner in the brand-new Golden Door Restaurant of the International Arrival Building.

But this wasn't all. The inspection and dinner followed an all-day Outdoor Lighting Clinic held in one of the Arrival Building Auditoriums. Included in this program were:

Mercury Vapor Light Sources by William Till, Westinghouse Electric Corp., Bloomfield, N. J.

Fluorescent Light Sources by Ralph Crockett, General Electric Co., New York, N. Y.

Self-Ballasting Lamps by Herbert Anderson, Duro-Test Corp., North Bergen, N. J.

Street and Highway Lighting by J. E. Tewart, Westinghouse Electric Corp., Cleveland, Ohio.

Area Lighting by Al Hart, General Electric Co., Nela Park, Cleveland, Ohio.

Outdoor Lighting Design for Idlewild by Abe Feder, Lighting Consultant, New York, N. Y.

The program was under the direction of Henry Wald, Wald & Zigas, Long Island City, New York.

Slate Chosen For Election of Officers

Nominations for 1958-1959 election of officers were reported to Council, February 13, by Duncan M. Jones, Chairman of the Nominating Committee. The slate to be offered for member ballot will be:

President: G. J. Taylor
First Vice-President: J. B. Browder, Jr.
Second Vice-President: R. G. Slauer
General Secretary: J. R. Chambers
Treasurer: G. F. Dean

Two Directors were also nominated: Joe Thomas of Montreal and R. P. Teele, Washington, D. C.

Ninth Electrical Show — Los Angeles, March 27-29

The 9th biennial Electrical Industry Show and 5th Electrical Maintenance Conference, sponsored by the Electrical Maintenance Association of Southern California, are being held concurrently at Shrine Exposition Hall, Los Angeles, March 27-29.

Ten topics are being discussed at the conference. These and the chairmen of the sessions are:

March 27

Small Industry Looks at Maintenance of Electrical Equipment — Frank R. Tharp, General Machinery Maintenance Co.

How to Estimate Additions and Expansions — Charles H. Hays, The Electrical Estimators, Inc., and The Plan Room, Inc.

Know Your Electrical Codes and Safety Orders — King D. Christopher, The Clark Controller Co.

Electronic Equipment Requires Maintenance — K. Lee Alvey, Airesearch Manufacturing Co.

Protective Devices Must Be Properly Selected and Maintained—T. P. Regas, Bulldog Electric Products of Los Angeles.

High Power Factor Can Pay Big Dividends — William H. Warren, Jr., Southern California Edison Co.

Electrical Insulation, Basic Concepts and Proper Maintenance — K. T. Shaw, Westinghouse Electric Corp.

Maintaining Proper Standards of Lighting Will Assure Peak Production — Urban Beh, consulting engineer, formerly with the General Electric Co.

Large Industry Plans Maintenance to Reduce Breakdown Losses — W. E. Cline, Los Angeles Apparatus Service Shop, General Electric Co.

Maintenance of Electrical Equipment in Commercial Buildings — Edmund Lanski, I-T-E Circuit Breaker Co.

In the session of lighting, under the chairmanship of Urban Beh, panel members and their topics will be: Joe Platt, The Holophane Co., speaking on lighting design, including calculations; A. L. Pryor, Southern California Edison Co., on uses of lighting in outdoor applications, such as parking areas, as well as safety and plant protection; and Frank Miller, Grayson Control Division of Robertshaw Fulton Co., on modern trends in lighting maintenance, covering the effect of general maintenance on lighting.

Members' Vote Will Divide New York Section

A poll of New York Section members soon to be made will present a choice of membership in that Section or in the recently-authorized New Jersey Section, headquartered in Newark. Currently the membership of the New York Section stands at 599, a large percentage of these members living and working in the northern New Jersey area. On petition of C. E. Waldron, Regional Vice-President, and at the instigation of both the New York and New Jersey groups, Council took action February 13 to establish the New Jersey Section. Granting of a Section-status Charter is, of course, contingent on the new group meeting the required membership of 50 or more.

ASHAE and ASRE Consider Merger

The Councils of the American Society of Heating and Air-Conditioning Engineers and the American Society of Refrigerating Engineers have unanimously approved a continuation of study preliminary to a merger of the two Societies. The reports of the Joint Committee on Cooperation, which is studying the proposal, will be presented to the membership of both groups at meetings during the spring of 1958.

Providing that a subsequent committee report is approved by the Councils in June, the Societies will present the method of merger to their members at 1958 summer meetings, and request approval to submit the proposal to a membership vote at the winter meetings.

1958 Regional Conferences, I.E.S.

Region	Place	Date
Northeastern	Statler Hotel Hartford, Conn.	April 10-11
East Central	John Marshall Hotel Richmond, Va.	April 14-15
South Central and Southeastern	Lafayette Hotel Little Rock, Arkansas	April 24-25
Southwestern	Washington Youree Shreveport, La.	April 28-29
Midwestern	Hotel President Kansas City, Mo.	May 1-2
Inter-Mountain	Whitman Hotel Pueblo, Colo.	May 8-9
South Pacific Coast	El Cortez Hotel San Diego, Calif.	May 12-13
Pacific Northwest	Multnomah Hotel Portland, Oregon	May 22-24
Great Lakes	Sheraton Hotel Rochester, N. Y.	June 23-24

Light Standards Compared On International Level

The National Bureau of Standards recently participated, together with the standardizing laboratories of France, Great Britain, Germany, Russia, Canada and Japan in a comparison of light standards conducted by the International Bureau of Weights and Measures at Sevres, France. Results indicated that the U. S. standards are within a few tenths of one per cent of the averages of those of the other participating nations.

The standards maintained by the Bureau, the national photometric units of the United States are periodically compared with similar standards of other countries to insure uniformity throughout the world. Comparisons with lamp laboratories in this country, which are also made regularly, insure standardization in this country.

The recent work at the International Bureau of Weights and Measures involved comparisons of photometric units for lamps of various color temperatures. With the average of all participating laboratories taken as unity, the values of the United States at these color temperatures were: 1.0031 for the candle at 2042 K; 1.0089 for the candle at 2353 K; 0.9995 for the lumen at 2353 K and 0.999 for the lumen at 2788 K.

Further cooperation among national laboratories is needed in order to reduce the spread in the values of the units. With this objective in mind, the Bureau is currently investigating its value for the candle at 2353 K, and plans to investigate its value for the candle at 2042 K. Results thus far indicate that the final value for the candle at 2353 K, as maintained at the Bureau will be much closer to the mean of the participating laboratories than is indicated by the 1.0089 value above. In addition, the Bureau is setting up the primary standard for recalibration of its basic candlepower standards. Recalibrations of other types of standards of light, in terms of these basic standards, are also planned.

Task Committee Continues Study of HQ Location

At its meeting February 13, Council heard a preliminary report from the Task Committee which is studying in detail factors influencing the location of Society headquarters. Marshall Waterman, Past-President, is chairman of the group. The Committee was continued in force to study further, numerous details relating to the matter.

The Long Arm of Coincidence

Lynn H. Morris, at Salem, Virginia, Registered Electrical Engineer and Sales Representative for a number of prominent lines including Century Lighting, Inc., Metal Craft Products Co., The Abolite Division of Jones Metal Products and Hadco Aluminum Products Co., is very much alive — and kicking — very properly, because the Post Office in Salem, *West* Virginia reported him "gone West." Seems that the dues invoice went to Salem, *West* Virginia by mistake and the Postmaster remembered another Morris.

Ohio State To Sponsor Engineer-Architect Conference

The Fifth Annual Conference for Engineers and Architects, sponsored by the Ohio State University College of Engineering has been scheduled for May 2 on the campus at Columbus. Principal speakers will be Major General John B. Medaris, commanding general of the U. S. Army Ordnance Corps' Ballistic Missile Agency at Huntsville, Ala., who will deliver the keynote address, and James C. Zeder, vice-president — engineering, Chrysler Corp., who will speak at the luncheon.

Four general technical sessions, each sponsored jointly by several departments in the college, will run concurrently in the afternoon. These include:

Satellites and Space Craft — Flight Mechanics of Orbital Bodies, Performance and Size of Rocket Launchers for Various Types of Orbits, Radio Telescopes and the Tracking of Earth Satellites, Physiological Aspects of Space Flight.

Nuclear Engineering — Current Trends in Nuclear Power Reactors, Nuclear Fuel Processing and Waste Disposal Problems, Metallurgy and Cost of Nuclear Fuel, Non-Destructive Testing of Nuclear Components.

Computers — Digital Computers — Principles and Applications, Analog Computers — Principles and Applications, Digital Computer Application to Highway Bridge Design, Analog Computer Simulation of Human Pilot Behavior.

Automatic Controls — Feedback and Control Systems, Application of Design and Analysis Techniques for Feedback Control Systems, Aeronautical Applications of Automatic Control, Effects of Random Variations in Control Systems.

Also scheduled for the afternoon are seminars in agricultural engineering, engineering drawing and metallurgical engineering, conducted by the respective departments.

Program and pre-registration information can be obtained from Associate Dean Harold A. Bolz, chairman of the Conference committee.

Social Security and The Self-Employed

The Department of Health, Education and Welfare, Social Security Administration, has issued the following reminder for the self-employed.

"There's no choice about being in social security. If you have an annual net income of $400 or more from your own business or nartnership, you must be covered. You have to pay the 3⅝ per cent social security tax on your net earnings from self-employment.

"Net earnings under the social security law are different from the amount you pay for income tax. The social security tax is aimed only at earned income. You disregard any returns from capital investments, unless you are a security dealer and the dividends or interest are re-

ceived in the course of your regular business. You also disregard gains or losses on the sale of capital assets and any income from real estate rents (unless you are a real estate broker).

"The 3⅜ per cent tax is imposed only on the first $4200 of self-employment income. Your self-employment tax is paid each year along with your U. S. Individual Income Tax Return. The form you must use, Schedule C of Form 1040 is part of your income tax return, and must be filed by April 15, 1958."

I.E.R.I. Annual Report, 1957

A brochure describing the structure, purpose, program and results of recent researches of the Illuminating Engineering Research Institute has been developed as the annual report of the Institute. A limited number of copies of this 25-page illustrated report is available from C. L. Crouch, Secretary of the Institute, at I.E.S. Headquarters, 1860 Broadway, New York 23, N. Y.

N. Y. Section Conducts Advanced Lighting Course

A ten-week advanced course in lighting design and layouts is being given by the New York Section from February 24 to April 28. Classes, which are being held from 6:30 to 8:30 on Monday evenings at the Consolidated Edison Building, 4 Irving Place, New York, N. Y., are for those who have attended an I.E.S. Fundamentals Course or have a knowledge of lighting. Special attention will be given to layout techniques and solutions to various problems and trends in commercial and industrial applications.

The faculty is comprised of J. Kerr, Public Service Electric & Gas Co., Newark, N. J.; W. Warren, Holophane Co., New York, N. Y.; G. J. Gillen, Consolidated Edison Co., New York, N. Y. and S. Halpert, General Electric Co., New York, N. Y. R. L. Zahour of Westinghouse Electric Corp., Bloomfield, N. J. is serving as coordinator of the sessions.

Program and instructors are:

February 24 — Interior Lighting Design — J. Kerr
March 3 — Design of Office and Classroom Lighting Installations, Part I — G. J. Gillen
March 10 — Office and Classroom Lighting, Part II — G. J. Gillen
March 17 — Office and Classroom Lighting, Part III — G. J. Gillen
March 24 — Lighting for Store Interiors, Show Windows, Display Cases, Part I — S. Halpert
March 31 — Store and Window Lighting, Part II — S. Halpert
April 7 — Industrial Lighting, Part I — W. Warren
April 14 — Industrial Lighting, Part II — W. Warren

(*Continued on page* 14A)

SCHEDULED EVENTS

March 25-26, 1958 — Inter-Society Color Council (27th Annual Meeting), Sheraton-Park Hotel, Washington, D. C.

April 10-11, 1958 — Northeastern Regional Conference, Statler Hotel, Hartford, Conn.

April 14-15, 1958 — East Central Regional Conference, John Marshall Hotel, Richmond, Va.

April 20-26, 1958 — Society of Motion Picture and Television Engineers, Ambassador Hotel, Los Angeles, Calif.

April 21-23, 1958 — Building Research Institute (Seventh Annual Meeting), Shoreham Hotel, Washington, D. C.

April 24-25, 1958—South Central and Southeastern Regional Conference, Lafayette Hotel, Little Rock, Ark.

April 28-29, 1958 — Southwestern Regional Conference, Hotel Washington Youree, Shreveport, La.

April 28-30, 1958 — National Association of Lighting Maintenance Contractors (Annual Convention), Statler Hotel, Cleveland, Ohio.

April 30, 1958 — Council Meeting, I.E.S., Hotel President, Kansas City, Mo. Members are free to attend meetings of Council as guests.

May 1-2, 1958 — Midwestern Regional Conference, Hotel President, Kansas City, Mo.

May 8-9, 1958 — Inter-Mountain Regional Conference, Whitman Hotel, Pueblo, Colo.

May 12-13, 1958 — South Pacific Coast Regional Conference, El Cortez Hotel, San Diego, Calif.

May 22-24, 1958 — Pacific Northwest Regional Conference, Multnomah Hotel, Portland, Oregon.

June 4-5, 1958 — Council Meeting, I.E.S., New York, N. Y. Members are free to attend meetings of Council as guests.

June 9-13, 1958 — National Association of Electrical Distributors, 50th Annual Convention, Civic Auditorium, San Francisco, Calif.

June 23-24, 1958 — Great Lakes Regional Conference, Sheraton Hotel, Rochester, N. Y.

June 23-27, 1958 — American Institute of Electrical Engineers (Summer General Meeting), Buffalo, N. Y.

August 17-22, 1958 — Illuminating Engineering Society (National Technical Conference), Royal York Hotel, Toronto, Canada.

August 19-22, 1958 — American Institute of Electrical Engineers, Pacific General Meeting, Sacramento, Calif.

September 22-25, 1958 — Institute of Traffic Engineers (Annual Meeting), McAllister & Columbus Hotels, Miami, Florida.

October 8-10, 1958 — Canadian Electrical Manufacturers Association (14th Annual Meeting), Sheraton Brock Hotel, Niagara Falls, Canada.

October 10-11, 1958 — International Association of Electrical Inspectors (Canadian Section), Toronto, Ont.

October 13-14, 1958 — U. S. National Committee of the International Commission on Illumination (C.I.E.), Annual Meeting, Nittany Lion Inn, State College, Pa.

October 13-15, 1958 — National Electronics Conference, Inc., Hotel Sherman, Chicago, Ill.

October 19-24, 1958 — Society of Motion Picture and Television Engineers, Sheraton-Cadillac Hotel, Detroit, Mich.

October 20-24, 1958 — National Safety Council (46th National Safety Congress & Exposition), Chicago, Ill.

October 27-31, 1958 — American Institute of Electrical Engineers (Fall General Meeting), Pittsburgh, Pa.

November 10-14, 1958 — National Electrical Manufacturers Association (Annual Meeting), Traymore Hotel, Atlantic City, N. J.

November 18-20, 1958 — American Standards Association (9th Annual Conference on Standards), Hotel Roosevelt, New York, N. Y.

January 19-23, 1959 — American Institute of Electrical Engineers (Winter General Meeting), New York, N. Y.

March 1-4, 1959 — National Electric Sign Association, Morrison Hotel, Chicago, Ill.

March 30 - April 1, 1959 — Chicago Electrical Industry Show, Hotel Sherman, Chicago, Ill.

I.E.S. National Technical Conferences

1958 — August 17-22 — Royal York Hotel, Toronto, Ontario
1959 — September 7-11 — Hotels Fairmont and Mark Hopkins, San Francisco, California
1960 — September 11-16 — Penn Sheraton Hotel, Pittsburgh, Pennsylvania
1961 — September 24-29 — Chase Park Plaza Hotel, St. Louis, Missouri
1962 — September 9-14 — Statler-Hilton Hotel, Dallas, Texas

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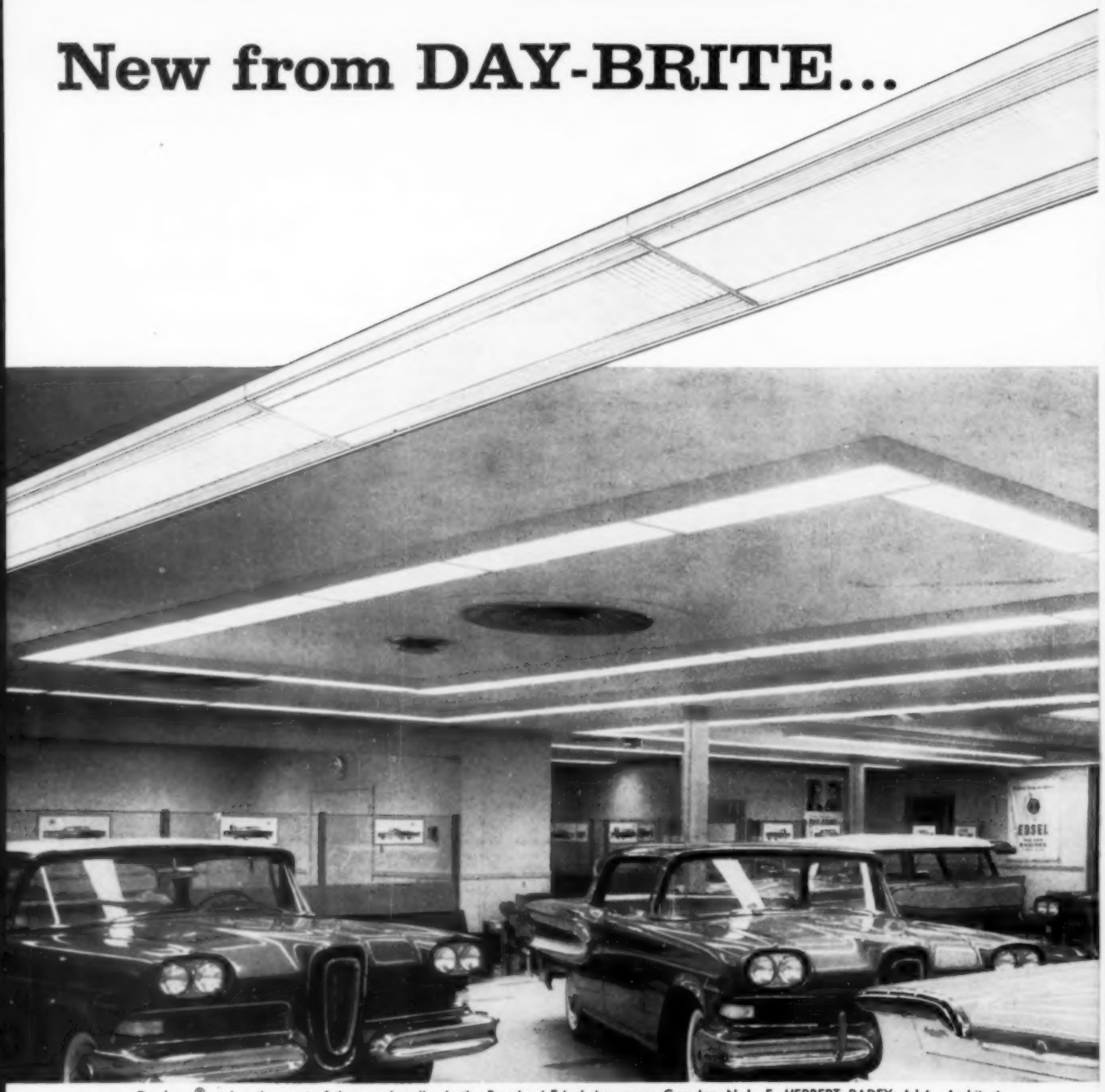

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DAYLUME WAS DESIGNED to meet contemporary architecture's needs for surface-mounted lighting elements offering *thinner profile, cleaner lines, lighter weight,* and *stronger construction* . . . to complement the "sleek surface" look in modern stores, offices, schools, and institutions. Recessed back plate design assures snug alignment with ceiling.

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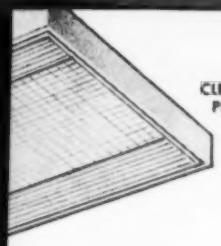

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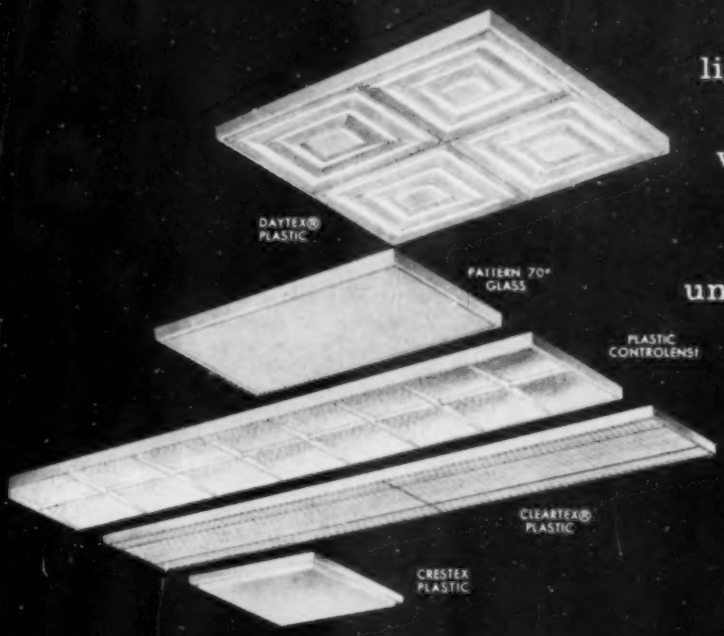

Open new opportunities in lighting effects and effectiveness. Combine recessed appearance with surface-mounted flexibility. Only 3¼ inches thin for today's lower ceilings. Available in an unusual variety of enclosures and sizes for extraordinary light control and layout possibilities. All this plus Day-Brite quality—the standard of the industry!

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Can be wired through sides, centers or ends for end-to-end, side-by-side, or end-to-side installation. Equipped with separately fused CBM ballasts.

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DECIDEDLY BETTER
DAY-BRITE®
Lighting Fixtures

NATION'S LARGEST MANUFACTURER OF COMMERCIAL AND INDUSTRIAL LIGHTING EQUIPMENT

(*Continued from page* 11A)

April 21 — Industrial Lighting. Part III — W. Warren
April 28 — General Review — R. L. Zahour

Tuition for the course is $10.00 for members of IES, AIEE, AIA and employees of IES sustaining members; $20.00 for all others.

Committee Reports Pending Indicate Active Year

As officer in direct contact with the technical program of I.E.S., George J. Taylor, first Vice-President, reported in detail to Council on February 13 on the current status of technical activity. Coming up for possible completion during 1958 are some 40 technical committee reports, several of them major Recommended Practices of wide interest. Three research projects are also nearing completion, Mr. Taylor said, and will probably be published within this year.

Four of these reports were presented to Council at the same meeting by C. L. Crouch, Technical Director. Accepted for letter ballot were: Recommended Practice of Marine Lighting, Recommended Practice for Hotel Lighting, Revisions of the Nomenclature Report, Guide for Reporting Engineering Data.

From the Historical Committee's Scrapbook

Interesting Things About Candles

Promptly after the opening of the United States Patent Office, the second patent in this country was granted to one Stacey Sampson of Boston, on August 6, 1790, for the manufacture of moulded candles.

The development of commercial photometry really expanded from about then on — or was firmly established at the beginning of the 20th century — and since this science was based upon the brightness of the (standard) candle-flame, or "candlepower," the scientist as well as the layman is interested.

Also, the beginnings of lighting fixture design rested in, and still largely remain in, the candle holder. Historical "Lamps," down the long list of Phoebe lamps, fish-oil or whale-oil burners, colza and lard-oil types, pentane lamps, Pintsch and manufactured coal or water gas, plus natural gas chandeliers and even electric residential luminaires, most were built where possible with the candlestick motif, or suggestive of a tallow candle.

The art of the small-wick candle is old. Dipped or rigid tapers and grease-soaked "vestas," of splints or reeds (guarded by Vestal Virgins), lighted man's way in Biblical legend, before Christ's birth. Hebrew 7-branch candlesticks were prominent, and in English legend good King Arthur is a father of the formed candle.

In southern New Jersey and along the New England coast, the berries of the bayberry bushes, or wax myrtle, when boiled down to a wax-like substance, were used to perfume the flame, or at least eliminate the rancid odor of burning fats — hence the "bayberry candle."

Tin or sheet copper candle moulds, for two up to seventy-eight candles, were much used in Colonial America between 1700 and 1800. In 1634 a good candle cost 4 pence (about 10 cents?) and it is not very different today. The cost of candle-light is not low. One 100-watt fluorescent lamp just about equals 350 "tallow" or paraffin candles, on a lumen basis. But it is the color and low brightness charm of the candle that makes it a considerable item in the petroleum industry, even after more than twenty centuries of history.

New Trends in Lighting — Feature At New Orleans Meeting

Over 300 people, from within a 200-mile radius of New Orleans, attended an exposition in that city of the latest developments for commercial, industrial, office and school applications. New Trends in Lighting was the topic of the speaker, William H. Kahler of the Westinghouse Electric Corp. Mr. Kahler discussed and demonstrated new sources and lighting design elements, at a meeting of the New Orleans Section held in conjunction with the exposition.

The event took place in the Claiborne-Beauregard Room of the St. Charles Hotel in New Orleans, January 14. Section Chairman Walter Faber presided.

Russian Technical Journals To Be Available in Translation

Translations of four leading Soviet scientific and engineering journals, *Electrical Technology, Radio Engineering and Electronics, Radio Engineering,* and *Telecommunications* will be offered to its members by the American Institute of

(*Continued on page* 17A)

NEW Trends in Lighting was topic of W. H. Kahler, photo at left, speaker at the January 14 meeting of the New Orleans Section. In photo at right, officers and committee chairmen are: l. to r., S. C. Berdon, Attendance; Walter T. Faber, Section Chairman; Mrs. Edna Fortier, Reception; Harold L. Salaun, Arrangements; Charles Kleinschmidt, General Chairman; George J. Segel, Secretary-Treasurer of the Section. Attendance was 330.

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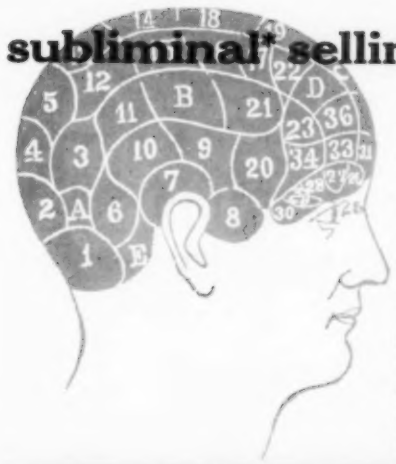

This attractive young lady is not the type that usually tries to spruce up her husband. But right now she's doing a great selling job because that's the most attractive suit she's ever seen. In fact, everything in the windows of Moore's new San Francisco store looks especially "buyable." The secret, of course, is in the lighting. Moore's uses display window ceilings of Honeylite to diffuse a soft, even, completely shadow-free light that makes window shopping a pleasure—buying a must. The outstandingly low surface brightness of Honeylite displays merchandise in its finest light—and it is subliminal* (below the threshold of consciousness). ■ Robert Israel, Moore's general manager in San Francisco, appreciates that modern lighting is a part of modern building and merchandising. That's why he chose Honeylite...light-diffusing aluminum honeycomb by Hexcel. ■ For prices and design information on Honeylite see your nearest lighting distributor or write Hexcel Products Inc., 2741 9th Street, Berkeley 10, California.

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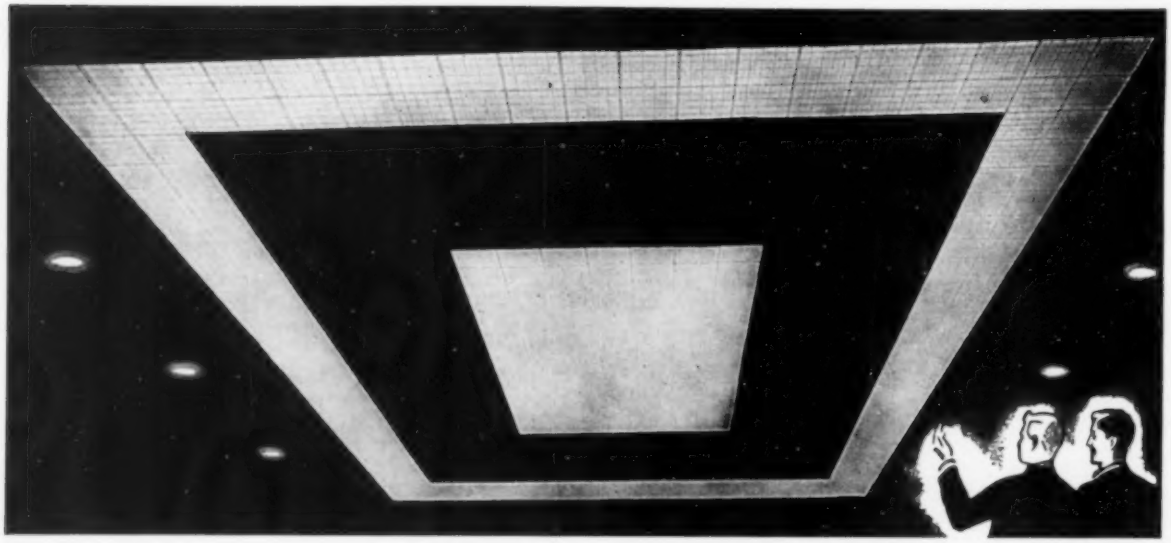

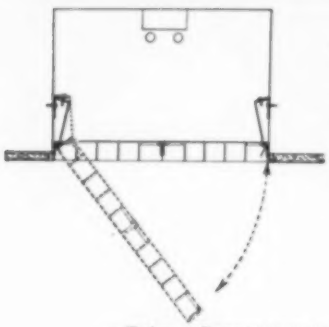

- "**Luve-Tile**" can be hinged down from either side or completely removed for cleaning.
- Hinging arrangement also holds the "**Luve-Tile**" firmly in position. No bars or channels are necessary.

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One-foot Square Louvred Panels Offer Practical, Creative Advances Over All Other Types —Particularly for Small Areas

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(*Continued from page* 14A)

Electrical Engineers. This program is being carried out by arrangement with the Permagon Institute of New York, a foundation organized to translate and distribute scientific and technical literature published in Russian and other Slavic languages.

With the assistance of the U.S.S.R. Academy of Sciences, copies of articles will be received by the Institute prior to publication in Russia. Titles, abstracts, and when necessary, complete articles will be reviewed by AIEE technical committees in association with the Massachusetts Institute of Technology to determine the quality and usefulness of the work, and its suitability for publication here.

In connection with *Electrical Technology*, the Permagon Institute will make available the full translation of any article listed by title or abstract, at a charge of $4.00 or less, per thousand Russian words, depending upon the number of orders for any given translation.

The distribution of these journals will aid in compensating for a widespread Russian language deficiency among U. S. scientists and engineers. It has been estimated that while over 80 per cent of the Russian scientists and engineers can read English, only 5 per cent of their American counterparts can read Russian.

Further information regarding these translations can be obtained from N. S. Hibshman, Secretary, AIEE, 33 West 39th Street, New York 18, N. Y.

UNIQUE "luminaire" combines many lighting systems, to provide a "laboratory" for suggested effects. The installation is a demonstration center at the Chicago Lighting Institute. Demonstrations include: Ceiling flooded with blue, gold, red or green light from fluorescent lamps. Walls tinted with red, blue or green light from incandescent lamps, or likewise, with fluorescent lamps. Cove lighting, from standard cool rapid start lamps, on a dimming ballast, controlled by a motorized dimmer. Direct and/or indirect fluorescent lighting; panels, alone or in combination with PAR38 floodlamps recessed and/or exposed; bare fluorescent in continuous rows and in grids, to name a few. Circuiting permits individual systems to be demonstrated, and many combinations.

Chapitre Québec Holds Full-Day Meeting

A three-part morning conference, with concurrent sessions, a joint luncheon and afternoon conference made up the Electrical Day meeting of the Quebec Chapter of I.E.S. Sessions were held at the Château Frontenac, the 13th of February. Papers and speakers at the three morning sessions were:

Conference pour les maitres-electriciens

L'entrepreneur, chef d'enterprise — L. A. Belisle, éditeur, écrivain et journaliste de Québec.

Meilleure connaissance de l'éclairage, gage assuré de prospérité — Oscar Dorval, ingenieur conseil.

Conference pour les marchands d'appareils

Forum — Où est le malaise dans le commerce des appareils et accessoires électriques?

Conference pour les ingenieurs, les manufacturiers, les distributeurs et les techniciens professionnels

A Current Review of the Nuclear Energy Business — J. L. Olsen, Manager, Marketing Research Product, Planning and Sales, Civilian Atomic Power Dept.

All members got together for the luncheon, at which Yvon R. Tassé, directeur-gérant, Bureau de l'industrie et du Commerce de Québec Metropolitan Inc., presided. Luncheon speaker was Henri F. Beique, directeur géneral adjoint de Quebec Power Co., who discussed the public utility's role in the electrical industry.

The afternoon session, for all present, was on La Canalisation du St. Laurent, with Paul E. Comtois, surveillant des travaux (Section de Montréal) Voie Maritime du St. Laurent, as speaker.

Tuition for the full day, including luncheon, was $5.00.

Conference/Show Planned For Design Engineers

Methods for achieving a better exchange of information among engineers will be a highlight among the topics to be discussed at the Design Engineering Conference in Chicago from April 14-17. The conference, sponsored by the machine design division of the American Society of Mechanical Engineers, will be held concurrently with the third annual Design Engineering Show. Both events will be at the International Amphitheatre.

At a luncheon on April 15, Dr. J. T. Rettaliata, president of the Illinois Institute of Technology, will address the conference delegates on Creativeness — Key to Industrial Progress.

Program and speakers are as follows:

April 14

Putting the Design into Production — Chairman, George F. Nordenholt, former editor, *Product Engineering*, New York; vice-chairman, Arthur Socolofsky, Acme Steel Co., Chicago; Leo Kevitt, Stewart Warner Co., Chicago; Joseph Manuele, Westinghouse Electric Corp., Pittsburgh, Pa.; Donald L. Harwood, Fairbanks, Morse & Co., Chicago; H. W. Regensburger, Link-Belt Co., Chicago.

April 15

Mechanical Session — Chairman, Colin Carmichael, editor, *Machine Design*, Cleveland, Ohio; vice-chairman, J. J. Stone, Jr., Battelle Memorial Institute, Columbus, Ohio.

Mechanical Memory Devices — Arthur Mirel, American Machine & Foundry Co., Greenwich, Conn.

Automatic Inspection — D. H. McConnell, Sheffield Co., Dayton, Ohio.

Materials Session — Chairman, H. R. Clauser, editor, *Materials in Design Engineering*, New York; vice-chairman, J. E. Johnston, Chicago Molded Products Co., Chicago.

Shock Resistance of Plastics — G. R. Rugger, Picatinny Arsenal, U. S. Army, Dover, N. J.

Uncommon Engineering Metals — J. P. Denny and L. F. Kendall, Jr., General Electric Co., Schenectady, N. Y.

(*Continued on page* 18A)

(*Continued from page* 17A)

Power and Control Session — Chairman, F. J. Oliver, editor, *Electrical Manufacturing*, New York; vice-chairman, T. A. Wetzel, Kearney & Trecker Co., Milwaukee, Wis.

Electro-Hydraulic Systems on Machine Tools — E. J. Rivoira, Cincinnati Milling Machine Co., Cincinnati, Ohio.

Electro-Hydraulic Systems on Aircraft — F. J. Moncher and L. D. Taylor, Vickers, Inc., Detroit, Mich.

April 16

Mechanical Session — Chairman, C. T. Blake, Warner & Swasey Co., Cleveland, Ohio; vice-chairman, G. A. Nothman, Armour Research Foundation, Chicago.

Problems in Designing Automatic Machinery — M. J. Faltot, New Jersey Machine Co., Hoboken, N. J.

Lubricant Considerations in Centralized Systems — R. K. Gould and R. D. Skoglund, Texas Co., Beacon, N. Y.

Materials Session — Chairman, Walter Starkey, Department of Mechanical Engineering, Ohio State University, Columbus, Ohio; vice-chairman, N. E. Bateson, Pullman-Standard Car Manufacturing Co., Chicago.

Compatibility of Metals in Bearing Contact — C. L. Goodzeit, General Motors Co., Detroit, Mich.

High Strength Structural Sandwich Construction — W. E. Kirkes, Wright Air Development Center, U. S. Air Force, Dayton, Ohio.

Power and Control Session — Chairman, E. M. Ramberg, Titeflex, Inc., Springfield, Mass.; vice-chairman, Sidney Davis, consulting engineer, Norwich, N. Y.

Integrating Mechanical and Electrical Design in Servo Systems — Walter L. McCann, Giddings & Lewis Machine Tool Co., Fond du Lac, Wis.

Solving Mechanical-Electrical Problems in Servo Systems — Glenn Ertell, General Electric Co., Waynesboro, Va.

April 17

General Engineering Session — Chairman, William Budington, John Crerar Library, Chicago; vice-chairman, E. H. Cann, Eastman Kodak Co., Rochester, N. Y.

The Information Center of Tomorrow — Allen Kent and James W. Perry, Center for Documentation and Communication Research, Western Reserve University, Cleveland, Ohio.

A Central Catalogue File Saves Engineering Time and Money — James L. Dykes, E. I. du Pont de Nemours & Co., Wilmington, Del.

"Clearinghouse" Set Up For Foreign Technical Publications

To assist in meeting the increased demand for scientific and engineering knowledge, the Department of Commerce has formulated a plan for increasing the dissemination of such information. Under the program, a Foreign Technical Information Center in the Department's Office of Technical Services will be established to act as a central clearinghouse for the evaluation and distribution of valuable scientific and technical literature. Arrangements have been made to obtain abstracts and translations of foreign technical articles, monographs and books from such agencies as the National Science Foundation, Atomic Energy Commission, armed services and intelligence agencies for distribution to United States scientists and engineers.

The new Center will operate a coordination service to eliminate duplication of translations among U. S. agencies, and in addition, have its own staff of engineer-translators, to review and analyze foreign publications, particularly in the field of technology.

To finance this project, Secretary of Commerce, Sinclair Weeks has requested a special appropriation of $300,000 in addition to the $1,250,000 already included in the 1959 budget for the Office of Technical Services.

In recent years, the Office of Technical Services has been collecting and publishing reports of government sponsored technical research, including abstracts and translations of foreign documents.

Council Meetings — 1958

Members of I.E.S. are invited to attend any meetings of the Council as guests, or to submit a communication for consideration on any matter through their Regional Vice-President or the General Secretary. Meetings of Council are scheduled for April 30, in Kansas City, Mo., and June 4-5 in New York City.

Plan Proposed For Easing Teacher Shortage

A four-point program for increasing the number of young teachers in engineering schools has been presented to Dr. James R. Killian, the President's Special Assistant for Science and Technology, by the American Society for Engineering Education. Aiming toward an increase in

(*Continued on page* 20A)

A Special Message to All I.E.S. Members

Midwestern Regional Vice-President Joseph A. Schneller recently addressed a letter to the Chairmen of all Sections and Chapters within the Midwestern Region in which he expressed some thoughts that we believe are applicable to every single member of our Society. We therefore recommend the following for your considered attention:

Your Privilege — The Society expects you to make a contribution, large or small, for the common good of the Society. Use your talents for the good of our Society instead of keeping them locked up in your own private world.

Your Opinion Counts — Don't forget for one moment that a good Section or Chapter, to be successful, needs the efforts and thoughts of each member.

Encourage One and All — Your Officers, both national and local, carry a heavy responsibility which could be lightened by your encouragement and offer of service.

Act Promptly — Once you have a constructive idea, waste no time in making your voice heard in behalf of your Section or Chapter's good and the Society's welfare.

Be Positive and Constructive — Make known your ideas at your Section or Chapter meeting. This is far more effective than negative criticism after action has been taken.

Attend Meetings — Meetings of the Sections and Chapters offer untold possibilities for the spread of good and new ideas. Be a booster, not a booter. You will enjoy it.

Speak at Opportune Times — If you have been blessed with good ideas, don't keep them to yourself. Add your contribution of thought for the good of the Society.

Be an IES Worker — Don't take a "Let George Do It" attitude, and let important Section or Chapter and National Committee jobs go by default. If you feel qualified to do a job, then let your willingness be known.

Remember . . . If two individuals each have an idea but keep it to themselves, then each has only one idea. . . . But, if they share their ideas with each other, then each individual has *two* ideas. If three individuals, each with an idea, share theirs with the others, then each individual has *three* ideas . . . and so on, to as many times as there are individuals involved.

Your National Membership Committee
Brooks Chassaing, Chairman

NEW... from APPLETON

24" High-Bay Mercury Vapor Lighting Units

higher production . . . fewer rejects . . . improved employee relations . . . extended safety records

more effective illumination at the work level!

Here is a precision-designed lighting unit for large industrial interiors and high-bay plant areas. High illumination levels without uncomfortable glare... Ventilated hood for lower operating temperature and minimum dirt accumulation... the new APPLETON 24" High-Bay Mercury Vapor Lighting Unit is a unique combination of technical features which give you more useable illumination at the work level. Available in: 1 pc. socket type construction or with the 2 pc. APPLETON DISKONECT time-saving maintenance feature. (Permits both lamp and reflector to be removed as a complete unit without disturbing wiring!) Reflecting surfaces are of ALZAK* processed aluminum. Available for concentrating or spread-type illumination distribution. For use with 1,000 Watt Mercury Vapor Lamps, this new APPLETON 24" High-Bay Mercury Vapor Lighting Unit is designed to meet your specific needs. As with all APPLETON Industrial Lighting Products... you can *see* the difference!

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Reelites

(*Continued from page* 18A)

both number and size of grants as a method for alleviating the shortage of teachers, the plan suggests these steps:

1. A substantial increase in the number of National Science Foundation fellowships for first year graduate study in engineering.

2. A program of secondary grants to those who fail to qualify for full fellowships under the National Science Foundation program.

3. Supplementary federal grants to holders of National Science Foundation fellowships who take part-time teaching assignments.

4. A new program of awards under the National Science Foundation to increase financial aid to those graduate students who combine teaching with their study and research.

There is already a shortage of 1,000 engineering teachers, and it is estimated that by 1966, 9,500 more will be needed. Since academic careers are not traditional for engineering graduates, as they are for scientists, the ASEE emphasizes the need for giving graduate students an opportunity to teach, and in this way, encourage them to enter the profession.

ABOUT PEOPLE

J. S. Walsh has been appointed Manager of Area Development for the Pacific Gas and Electric Co., with responsibilities of bringing new industry into northern and central California. Filling Mr. Walsh's former position as Director of Commercial Sales is **Stanley O. Blois,** and **R. L. Sawyier, Jr.** has been named Chief Illuminating Engineer.

By unanimous action of Council, at its February 13 meeting, **C. J. Berry** (Maryland Section) and **R. N. Falge** (Indiana Section) were elected Members Emeritus of the I.E.S. Mr. Berry retired January 1 from Baltimore Gas and Electric Co., and Mr. Falge retired last November 1 from the General Motors Corp., Guide Lamp Division.

R. J. Mors has been appointed general sales manager of the Benjamin Electric Mfg. Co., Des Plaines, Ill. This appointment follows a long career with the Benjamin Co. Mr. Mors started in the sales service department, later served as sales representative in the Chicago and Kansas City territories, and for the past 11 years was assistant sales manager.

Walter Sturrock

Walter Sturrock, consulting engineer for General Electric's Large Lamp Department at Nela Park, concluded a 41-year association with the company with his retirement on February 1. His latest assignment had been as liaison for G-E with the United States government, for both military and civilian work. A Fellow and Past-President (1950-1951) of I.E.S., Mr. Sturrock has served on many of its technical and general committees, and for seven consecutive years was a member of Council. He is currently on the Committee on Constitution and Procedure and the Committee on Student Membership.

Harry A. Hillman has been named assistant to **John Myers,** president of Westinghouse Electric Supply Co. Mr. Hillman will be concerned with personnel programs both within the supply company, and in coordination with other divisions of Westinghouse.

Two new appointments in the Lamp Division of Westinghouse have also been made known. **Howard J. Thomas** has been promoted to the position of manager for wholesale and utility sales. He will make his headquarters in Bloomfield, N. J., and be responsible for activities concerning utilities, rural electrification administration and wholesale distributors. Replacing Mr. Thomas as district sales manager in Cincinnati is **Donald M. Canfield,** who moves up from assistant to the Central Region sales manager.

Gerald Marks announces the formation of a new company, Lighting Associates, with offices at 53 West Jackson Blvd., Chicago. **Robert Harmon** and **Wesley Whitchurch** are partners in the firm which will represent Electro-Silv-A-King and the Art Metal Co.

Four new divisional vice-presidents have been appointed at Sylvania Lighting Products, Inc., Salem, Mass. **Henry F. Callahan,** former general sales manager is vice-president—lighting products; **O. Howard Biggs,** chief engineer becomes vice-president—engineering; **Garlan Morse,** the new vice-president—lighting sales was previously general sales manager; and **George C. Connor** moves up from general sales manager—photolamps to vice-president—photolamps.

Charles W. Sanford has joined Crouse-Hinds Co., Syracuse, N. Y., as vice-president—manufacturing, succeeding the late **Albert H. Clarke.** Mr. Sanford was most recently manager of foreign operations for Philco Corp., Philadelphia.

Swivelier Co., Inc. of New York announces the appointment of **Matt Cabot** and Associates, Honolulu as its sales agent in Hawaii.

Two new appointments have been made in the photo lamp department of the Westinghouse Lamp Division. **Frederick H. Rixton** has been named manager of commercial engineering and **Earl J. Aberle,** manager of manufacturing and engineering. Mr. Rixton, who joined Westinghouse in 1942 was most recently engineering manager of the department. Mr. Aberle has been promoted from manufacturing manager.

Milton Price has joined Day-Brite Lighting, Inc., St. Louis, in the new product development division. Prior to this association, Mr. Price was president of Arterest Manufacturing Co., Chicago.

Garey Lighting, Chicago, has signed two new sales representatives, **Hal Beard** of 166 Monroe Ave., Memphis, and **R. Paul Talbot,** 529 South Seventh St., Minneapolis.

(*Continued on page* 22A)

Exercise your privilege to vote . . .

in the election of National and Local I.E.S. Officers and on other Society changes. Your ballots should be reaching you early in April.

Sylva-Lume—good lighting with attractive, variable design—strikes up a warm and friendly mood at the central offices of the Hill City Savings & Loan Association, Summit, N. J. Architect: R. O. Peck, Westfield, N. J. Consulting engineers: Nordling-Dean, Inc., Summit.

Sylva-Lume Wall-to-Wall Lighting . . .

combines arresting, aesthetic design with finest quality of illumination

An aesthetic ceiling design of square modules that glow with soft, diffused light! That's the impression you get when you see Sylvania's new Sylva-Lume lighting system.

A delight for the designer's eye . . . a lasting pleasure for the man who works under it . . . Sylva-Lume wall-to-wall lighting rediscovers the ceiling as a medium of contemporary expression. Its translucent plastic squares have "sculptured" contour, with varying depth and design. Optional incidental color lends splashes of accent and variety to the pattern. Individual designs can be changed quickly and easily when desired.

Sylva-Lume enables you to combine unlimited freedom of design with the finest quality of illumination attainable. Its true shadow-free, glare-free effect is ideal for general and private offices, reception rooms, lobbies, department stores . . . wherever good lighting counts. Ask your Sylvania Fixture Specialist for his "live" demonstration, or write direct for FREE folder of complete information and specification data.

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Custom-create over 100,000 different lighting designs using only a few standardized components:

Deep panels • 4 types. In pink, yellow tints, or white.

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Drumhead panels • 8 types. White, pink, yellow . . . in several pleasing combinations.

Perimeter panels — Interesting treatment for borders.

Acoustic baffles—White, yellow or blue—delineate and accent.

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Fluorescent Lighting Fixtures and Systems

Best fixture value in every price range

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(*Continued from page* 20A)

Gwilym F. Prideaux

Gwilym F. Prideaux, consultant and senior specialist in charge of miniature lamp applications for the General Electric Miniature Lamp Department, retired March 1, after more than 35 years in the lighting industry. A Fellow of I.E.S., Mr. Prideau was also the recipient, in 1933, of the Coffin Award, General Electric's highest award.

Ray F. Hurley has been named to the newly created post of industrial designer at Benjamin Electric Mfg. Co. In this position, he will work with and supplement the product design, development and engineering staffs. Prior to joining Benjamin, Mr. Hurley was chief designer for Curtis Lighting, Inc.

The Board of Directors of Silvray Lighting Inc. and Associated Companies, Bound Brook, N. J. have elected **Frederick A. Bohn** as assistant vice-president. Mr. Bohn, whose duties will include supervision of the lamp processing division and development of special processes, started with the company in 1936.

The partnership of Rebmann & Gay, St. Louis, Mo., has been expanded into the partnership of Rebmann, Gay, Herold, Consulting Engineers. Active members of the firm will be **Charles P. Rebmann, Clarence E. Gay, Jr.**, and **George F. Herold.**

Eugene C. Pauly has been appointed manager—indoor sales for General Electric Co., Ballast Department, Danville, Ill., according to a recent announcement. Mr. Pauly, formerly a sales specialist for the department succeeds **Arthur Rowe** who has been named district sales representative of the company's Apparatus Sales Division in Los Angeles.

Litecraft Manufacturing Corp. has made known two new appointments in its sales division. **Earl F. Miles** has been made national sales manager, and **Sidney Sheldon** New York sales manager, with responsibility for the Metropolitan New York area, including Long Island, Westchester and New Jersey.

Paul E. Sheppard has been appointed staff representative for the electrical equipment and public utilities sections by the National Safety Council, Chicago. Prior to this connection, Mr. Sheppard was safety director for the city of St. Petersburg, Fla.

Kuhlman Electric Co., Birmingham, Mich. has announced the appointment of **Perry M. Green, Jr.** as general sales manager of the company's Transformer Division, effective February 17. Mr. Green will supervise sales activities of 56 sales offices and three regional factories at Bay City, Mich., Crystal Springs, Miss., and Salinas, Calif.

John C. Virden Co., Cleveland, has named **Ned P. Walters** sales representative for the area including Alabama, Georgia and Pensacola, Fla.

Kenneth F. Tupper of Toronto has been elected president of the Engineering Institute of Canada for 1958-1959. He will take office in May, at the Annual Meeting of the Institute at the Chateau Frontenac, Quebec.

BOOKS AND PAMPHLETS

*Books whose reviews are marked * are available for inspection at I.E.S. Headquarters Office, Technical Department.*

***The Focal Encyclopedia of Photography,** Frederick Purves, Editor; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; 1957; 1468 pages; illustrated. $20.00.

This comprehensive British book has alphabetically arranged entries — from "Abaxial" to "Zoom Lens"—and includes such subjects as photographic lighting equipment, vision, illumination, lighting the subject, color, and projection and viewing — all of which should be of interest to the illuminating engineer.

The aim of this book is to provide the photographer with a comprehensive source of reference, free of obsolete information and easy to consult. Entries consist of definitions and biographies and of articles signed by the authors and referenced. There are over 1500 pictorial diagrams and 400 photographs to illustrate equipment, methods and theories.

Technical Report Writing, James W. Souther, published by John Wiley & Sons, 440 Fourth Ave., New York, N. Y., 70 pp., $2.95.

Mr. Souther, associate professor of humanities and social studies at the College of Engineering, University of Washington, has written a guide to the preparation and writing of scientific and engineering reports. He begins with an analysis of the objectives of the report, and follows the steps involved from gathering of materials to the preparation of the final copy. Included also is an appendix which contains a check list for the finished report on the mechanics of abbreviation, documentation and equations; reproduction processes; and a sample report.

Municipal Public Works Administration, published by The International City Managers' Association, 1313 East 60th St., Chicago 37, Ill., Fifth Edition, 1957, 449 pages, illustrated and indexed. $7.50.

The purpose of this book is to set forth procedures and techniques that can be applied in the management of municipal public work. It therefore approaches public work problems from the point of view of those who are charged with the responsibility for municipal public works.

There is a chapter on street lighting which includes such headings as: "Available Light Sources for Street Lighting," "Modern Street Lighting Practice," "Maintenance," "Operating Practice," "Cost of Adequate Street Lighting," "Long-Range Planning of a Modernization Program" and "Financing the Street Lighting System." All material has been brought up to date from the previous edition of 1950. The portion on lighting practice is based on the current "American Standard Practice for Street and Highway Lighting."

Demand for Engineers, published by Engineers Joint Council, 29 West 39th St., New York, N. Y., $1.00.

The 1957 edition of the EJC survey on employment opportunities for engineers is now available at EJC headquarters.

More Housepower to You, a comic book dealing with the adequate wiring problem is now available from the Wire and Cable Section of the National Electrical Manufacturers Association.

The book, which tells the blackout story of "octopus outlets" is designed for use as a mailing piece to utility customers, a give-away item at home shows, and for distribution by electrical contractors.

(*Continued on page* 41A)

WHY THE ORIGINAL IS STILL THE BEST—

EXTRULITE® R1

**The first extruded and patterned plastic panel designed exclusively for the Lighting Industry.
Copied, after a fashion, but never equalled in either performance or appearance**

Here's Why:

TESTS PROVE, not only our own, but Tests of Five Independent Manufacturers show that Pattern R 1 offers

- Superior Light Control
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Eleven Full Page National Ads have helped to Build Acceptance and Pre-Sell our Product with More Publicity scheduled

Produced in 1 ft. and 2 ft. nominal widths

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NEW EQUIPMENT DATA
AVAILABLE WITH COUPON

New manufacturers' catalogs and bulletins listed below are available free to readers of ILLUMINATING ENGINEERING by mailing the coupon. Circle the numbers of those items which you want, drop in envelope or fasten securely to back of 2-cent postcard addressed to Publications Office.

(1) BALLAST DATA. New Fluorescent Lamp Ballast Data Book contains information on ballast circuits, fluorescent lamp ballast construction, various ratings and other pertinent data covering this subject. Advance Transformer Co., Chicago, Ill.

(2) EXIT SIGNS of company's new 45R Series designed for inconspicuous recessed ceiling installation; fixtures are edge-lighted and catalog page gives full particulars as to dimensions, construction and installation. McPhilben Mfg. Co., Brooklyn, N. Y.

(3) SERVICE STATION ISLAND LIGHT is described in bulletin which gives full details and illumination data on four- and six-lamp fluorescent luminaires with chart showing footcandle readings at varying distances from installation. Columbia Electric & Mfg. Co., Spokane, Wash.

(4) MERCURY VAPOR FLOODLIGHTING is covered in comprehensive 16-page brochure on new line; details operating and color characteristics of currently available lamps with thorough section on ballast selection and specifications on floodlight housings from 10" to 23" sizes. Pyle-National Co., Chicago, Ill.

(5) PLASTIC PANEL SHAPES. Illustrated brochure shows in actual size cross-sections of 50 extruded shapes for use in luminaires, including Extru-Lite Pattern R1; gives specifications for ordering and shows stock sizes. Rotuba Extruders Inc., Brooklyn, N. Y.

(6) SCHOOL LIGHTING is outlined in eight-page, two-color booklet titled "What to look for in school lighting"; non-technical, basic coverage of factors making for efficient classroom illumination, including quantity, comfort and economics. Garden City Plating & Mfg. Co., Chicago, Ill.

(7) ADJUSTABLE HANGERS designated Triplex by manufacturer are described in Bulletin TR-57 and are designed for extra heavy luminaires of all types. Hangers enable one workman at floor-level to lower, relamp, clean and then reposition heavy hi-bay lights. Thompson Electric Co., Cleveland, Ohio.

(8) ANTENNA TOWER LIGHTING. Catalog pages describe various FCC and CAA specifications and requirements for unique lighting problem for which company assembles complete lighting kits as well as controls and obstruction units. Hughey & Phillips Inc., Burbank, Calif.

(9) SHALLOW LUMINAIRES are featured in eight-page, two-color Bulletin O which describes company's new line of surface-mounted fluorescent luminaires; Cleveland available in 4' and 8' lengths and the modular Shallowline in 4' and 2' squares; gives full details of construction, installation and illumination data. Pittsburgh Reflector Co., Pittsburgh, Pa.

(10) OUTDOOR FLUORESCENT LIGHTING is covered in four-page bulletin GEA-6441A which discusses this type of lighting for streets and highways; large service and parking areas and others; cites advantages and features with use of Power Groove lamps. General Electric Co., Schenectady, N. Y.

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(11) ANTI-STATIC COMPOUND called Merix Wipe especially for heat-exposed plastic surfaces is described in single-page sheet which gives details as to application to lighting fixtures and chemical data as well as prices. Merix Chemical Co., Chicago, Ill.

(12) LIGHTING CONTROL EQUIPMENT. 12-page two-color folder announces company's new line of lighting control equipment from basic dimmer modules to complete stage-board console systems including Pak-Trol for use in limited areas such as schools, churches, etc. Vickers Inc., St. Louis, Mo.

(13) TROFFERS. New eight-page 700 Series catalog gives complete details on company's line of "miniature" troffers, 5" wide and 4" deep, which are available along with 8"- and 12"-wide troffers with a variety of diffusers and in various lengths and frame finishes. Alkco Mfg. Co., Chicago, Ill.

(14) HIGH BAY FIXTURES in industrial applications for mercury and incandescent lamps are described in new four-page catalog; gives complete information with performance data on Alzak aluminum and porcelain enamel luminaires. Abolite Lighting Div., Jones Metal Products Co., W. Fafayette, Ohio.

(15) WALL BRACKETS. Catalog No. S-22 includes company's diecast aluminum wall bracket and ceiling incandescent luminaires for use in interior or exterior commercial installations; shows construction details and materials. Prescolite Mfg. Corp., Berkeley, Calif.

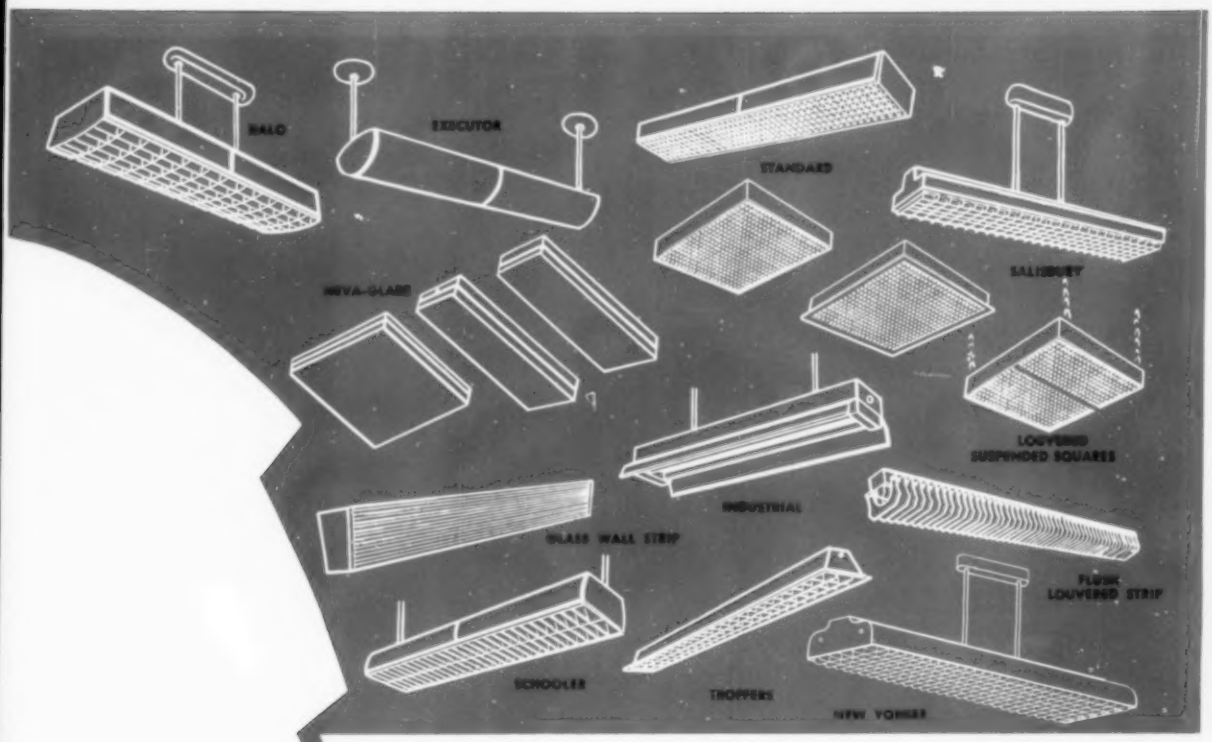
(16) SUSPENDED CEILING SYSTEMS. Eight-page folder shows aluminum suspended ceiling systems of four types for lighting and acoustical tile suspension; gives construction details and specifications including installation data. Lok-Products Co., Los Angeles, Calif.

(17) STREET LIGHTING CONTROL without vacuum tubes is described in Bulletin 101; hermetically sealed replaceable cell replaces phototube, said to show life expectancy up to ten years. Gives complete description and typical installation data. Micro Balancing Inc., Garden City Park, N. Y.

(18) HIGH FREQUENCY FLUORESCENT. Company has assembled all available information on high-frequency, high-voltage lighting installations for easy use and included catalog pages and prices of their own varied line of incandescent and fluorescent luminaires. The Wakefield Co., Vermilion, Ohio.

(19) UNDERWATER LIGHTING. Two types of underwater floodlights are described in Bulletin 2638; type SPS for use where manhole or passageway can be provided; RPS for other types of installation; includes diagrams and dimensions for both. Crouse-Hinds Co., Syracuse, N. Y.

(Continued on page 49A)



EYES *RIGHT*..

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Above all else, correct lighting is the essence of easy-on-the-eyes illumination. And, above all else, Marlou Fixtures provide modern eyes-*right* lighting because they're opthalmically correct in design and construction.

Marlou manufactures fluorescent lighting fixtures for countless standard and special applications in stores, schools and other institutions, commercial buildings, laboratories and industry.

- Fluorescent and Slimline for direct and reflective lighting
- Single unit and continuous installations
- Stem, recessed and flush-mountings
- Easy installation and convenient maintenance
- Union-made and Underwriter's Laboratories approved

Complete information and illustrated catalog will be promptly sent upon request. Ask for yours TODAY!

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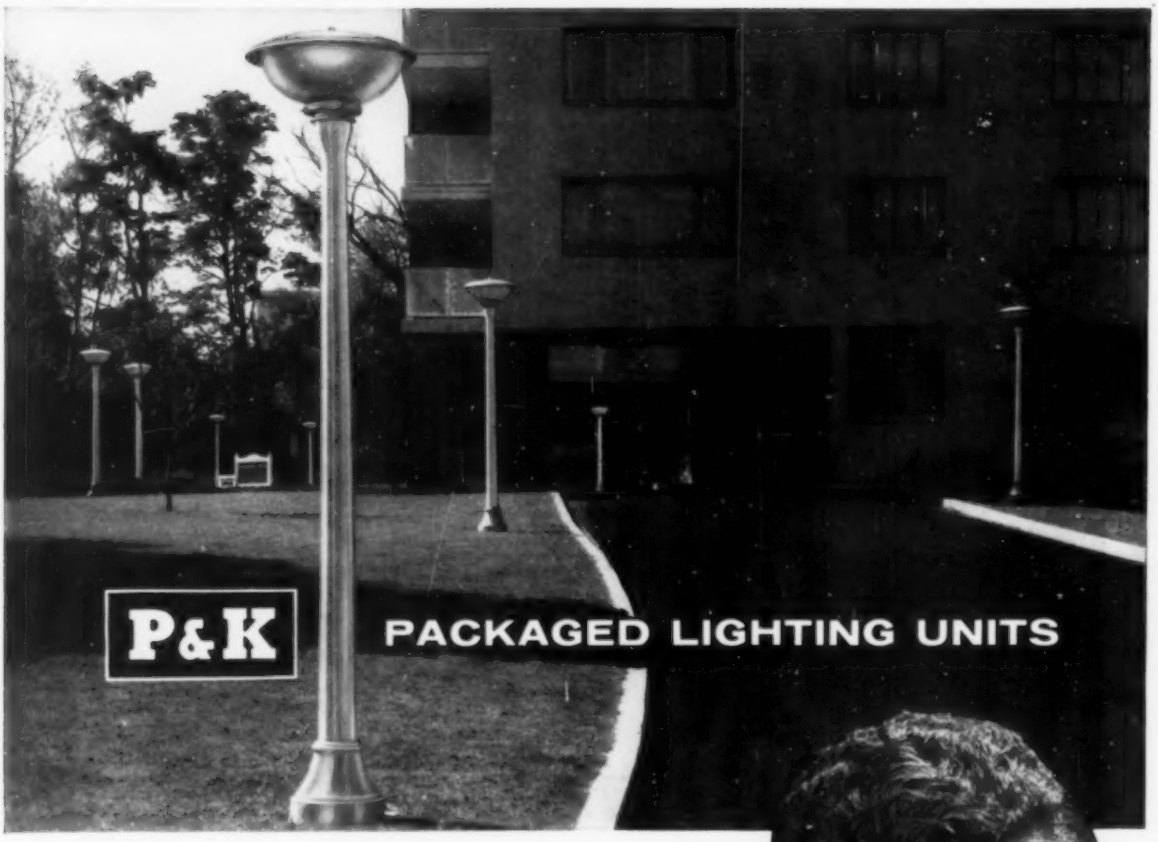

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"When Harrison Park wanted to provide lighting for the grounds of their new luxury apartments—they chose P & K packaged units—in keeping with the handsome buildings and surroundings. Thus, from one source, they were able to select pedestal and lighting units, with such a wide choice in each that they effectively customized their installation with standard components."

For example, you can choose from a wide range of conventional designs—davit or straight—as well as many more advanced shapes for any particular lighting requirement for residential, commercial, industrial, and street lighting applications. Whatever you choose, P & K's seamless, tapered, all-aluminum construction assures high strength, ease of installation, and absolutely no maintenance.

YOUR CHOICE OF 3 LIGHT SOURCES

Yes, in addition, to matching standards or pedestals, you also select the light source best suited to your needs—incandescent, fluorescent or mercury vapor.

Harrison Park chose the P & K package unit consisting of a CIRCLElux incandescent post top unit, and a slim, tapered ten-foot aluminum pedestal.

How sensible to match components to form a packaged unit to your own specifications—achieving the effect you want with a minimum of cost and a maximum of convenience. Send today for your copy of the P & K catalog L-2.

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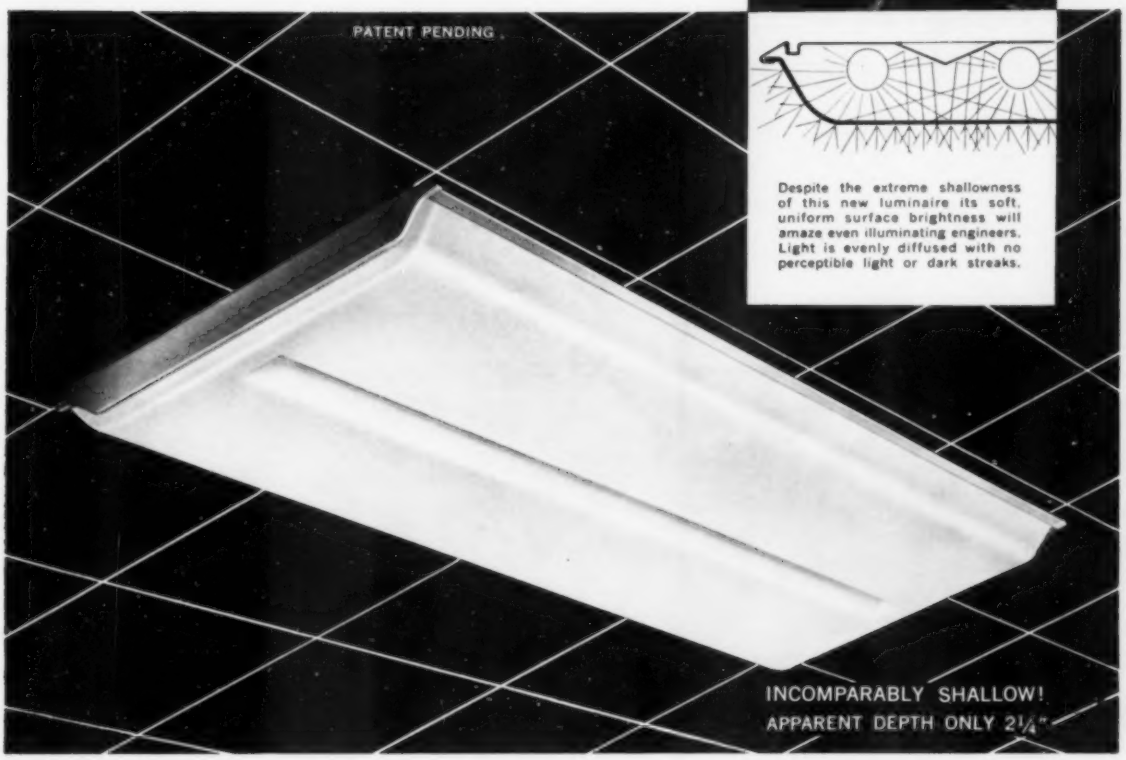
IT'S SURFACE MOUNTED—BUT LOOKS RECESSED!



Despite the extreme shallowness of this new luminaire its soft, uniform surface brightness will amaze even illuminating engineers. Light is evenly diffused with no perceptible light or dark streaks.

The Fixture Setting Amazing New Latitudes in Lighting

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- 2- and 4-lamp units for widest range of applications; banks, institutional spaces, general or private offices, etc. Ideal for re-lighting.
- No latches, no hinges, no visible hardware. Installs lightning-fast.
- Diffuser opens on continuous hook-up supports by hand from either side.
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Another great engineering first from metco Lighting

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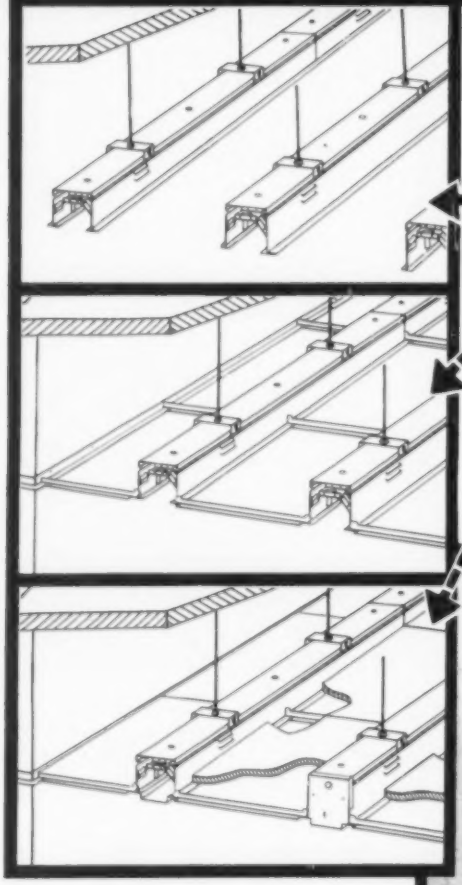
The lighting supports the ceiling!



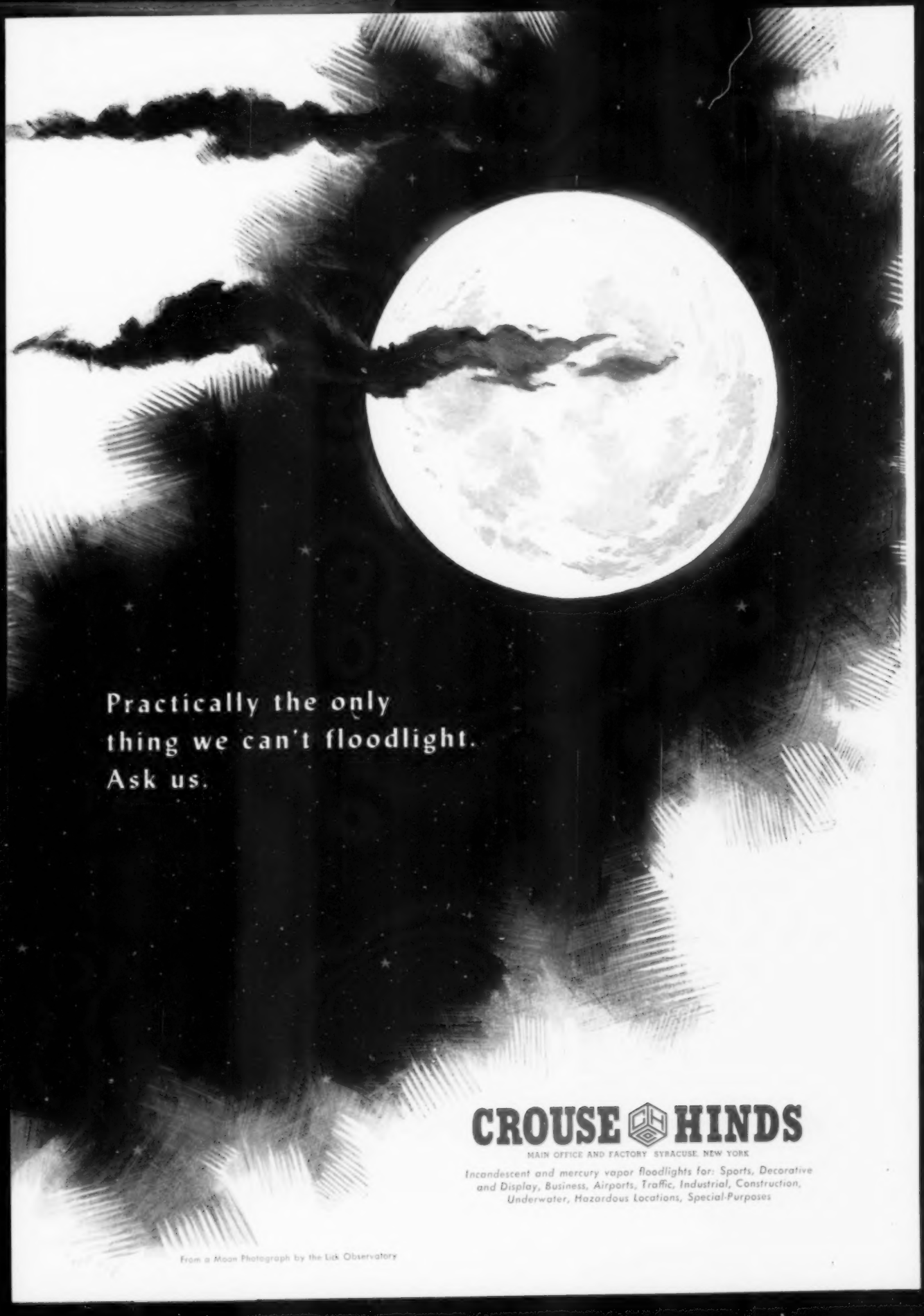
NEW KIND OF LIGHTING AND ACOUSTICAL CEILING SYSTEM CUTS CONSTRUCTION COSTS

1. Install METCO QUIET-LIGHT recessed troffers. Space troffers for any desired illuminating level.
2. Install wall angles. Insert QUIET-LIGHT spacer bars between troffers and wall angles and rows of troffers.
3. Lay in acoustical panels on flanges of troffers, spacer bars and wall angles. Insert extruded polystyrene plastic diffusers in troffers.

RESULT:

Evenly diffused wall-to-wall quality lighting with efficient acoustics at lower cost . . . for offices, schools, libraries, drafting rooms, corridors, homes. Write for catalog and specification sheet today! **SOLD ONLY THROUGH QUALIFIED ELECTRICAL DISTRIBUTORS**

METALCRAFT PRODUCTS COMPANY, INC., MASCHER & LIPPINCOTT STS PHILADELPHIA 33, PA



CROUSE HINDS

MAIN OFFICE AND FACTORY SYRACUSE, NEW YORK

Incandescent and mercury vapor floodlights for: Sports, Decorative and Display, Business, Airports, Traffic, Industrial, Construction, Underwater, Hazardous Locations, Special-Purposes

From a Moon Photograph by the Lick Observatory

"Yes, sir, the cost analysis on one-at-a-time lamp replacement? I've got it right here!"

Six years ago, engineers at Western Electric's Indianapolis Works discussed *their* lighting cost analysis with General Electric specialists.

One-at-a-time replacement, they learned, took 20-23 minutes per lamp. Labor cost of replacing a lamp often exceeded the lamp price itself. Plant production and office work slumped whenever men appeared with ladders.

Western Electric tried General Electric's Simplified Relamping Plan, as a test, on 3000 office lamps. Maintenance men, working after hours, changed *all* the lamps, dead or alive. It took them 2½ minutes per lamp!

Impressed, Western Electric then Group-Relamped 15,000 lamps in the plant. Replacement time there was cut to less than 4 minutes — a saving of 3700 hours!

They now Group Relamp every two years. Lighting levels are up. Office and plant look better. Maintenance savings are almost $3000 per year!

Start your customers and clients on the road to better lighting at lower cost. For the complete story on the G-E Simplified Relamping Plan, see or write your local General Electric Large Lamp Salesman.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Now . . . a troffer so shallow it handles like tile!

SMITHCRAFT SLENDEX

Introducing the slender, sleek Smithcraft SLENDEX. A unique, practical answer to the absolute *minimum cavity – low ceiling* conditions dictated so often by today's construction economies. Recesses only 1⅜" . . . less than the depth of most ceiling supporting members . . . eliminates cost of cutting these members. One-man installation. Goes in FLAT, requires no extra depth for tilting. Adapts to most of today's common ceilings. 1' x 4' units for 2 Rapid-Start Lamps or 2' x 4' units for 4 Rapid-Start Lamps. Here is a clean, smoothly-styled lighting answer to a common contemporary building problem . . . simple, efficient and pleasing!

SLENDEX *Surface Units are shallow, too. Slim, trim and clean, with no light leaks, and with no dark center streak. Fixture depth 1⅜" — overall depth, including shielding, only 3".*

Smithcraft — "AMERICA'S FINEST FLUORESCENT LIGHTING"

Smithcraft LIGHTING
CHELSEA 50, MASS.

THE MAN FROM SMITHCRAFT
Paul Wehner, Dayton, Ohio representative. Like every member of Smithcraft's nationwide organization he can help you turn any lighting purchase into a profitable lighting investment. Ask the man from Smithcraft about the new SLENDEX.

PLEASE ATTACH TO YOUR BUSINESS LETTERHEAD and mail to

Smithcraft LIGHTING, CHELSEA 50, MASS. IE-3

NAME _____

TITLE _____ CO. _____

ADDRESS _____ CITY _____ STATE _____

☐ Please send me the monthly publication, "Light Side of the News", so that I can keep in touch with the latest trends in lighting.

☐ Please send me catalog information on the NEW Smithcraft SLENDEX.

☐ Please send me the complete SMITHCRAFT CATALOG, containing data on America's Finest Fluorescent Equipment.

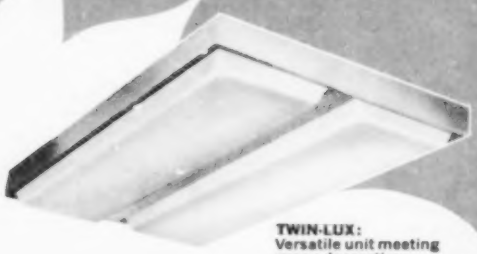
SMOOT-HOLMAN

your

best source

for

"tomorrow's lighting today"



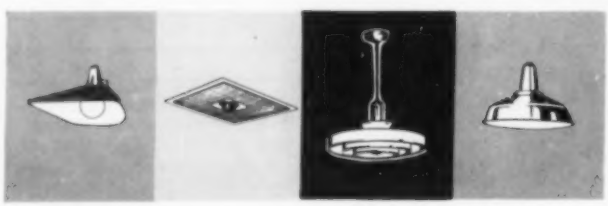
TWIN-LUX:
Versatile unit meeting many decorative requirements.

PERFECT VISION:
A Smoot-Holman exclusive for quality illumination at low cost.

SHALLOLITE:
Outstanding styling coupled with top lighting performance.

INDUSTRIAL FLUORESCENT:
Quality construction designed to RLM standards.

A complete selection of commercial fluorescent, industrial fluorescent, commercial incandescent, industrial incandescent and outdoor flood lighting equipment.



PROPER LAYOUT MADE EASIER! Send for your FREE Smoot-Holman "Lighting Guide" ... and auto-calculator to compute the required lamps and fixtures for most commercial and industrial interiors.

Certified Lighting

SMOOT-HOLMAN COMPANY · *Inglewood, California*

FIRST FROM JEFFERSON—— *ONLY* FROM JEFFERSON

NEW ONE CAN BALLASTS

FOR 4 FT., 6 FT. AND 8 FT. POWER GROOVE AND VHO LAMPS FOR COLD WEATHER OPERATION

New one can design saves up to 8 pounds per unit — or up to 12-11/16" length per unit over comparable 2 can ballasts.

YOU GET:

- less shipping weight
- smaller, more streamlined fixtures
- much easier assembly

		JEFFERSON Single can			COMPETITIVE 2 can or its equivalent	
LAMP	TEMP.	CAT. NO.	LENGTH	WEIGHT	LENGTH	WEIGHT
4'	0°	254-771	19 3/16"	17 lbs.	28 3/16"	25 lbs.
6'	−20°	254-781	25 5/16"	25 lbs.	38 3/16"	32 lbs.
8'	0°					

2 CAN BALLASTS FOR 6 AND 8 FT. LAMPS ARE AVAILABLE

Jefferson FLUORESCENT LAMP BALLASTS

JEFFERSON ELECTRIC COMPANY • BELLWOOD, ILL.

Revere Outdoor Lighting Report

A timely discussion of an outdoor lighting problem and its solution, prepared for lighting engineers, lighting planners, and architects who may have similar outdoor lighting problems.

Lighting Chicago's "Auto World" Super Service Station

This unique new service station features an auto accessory store and "Speed-Kleen" car wash in addition to its regular auto services. The lighting installation had to be a "standout" to keep pace with this advanced station design.

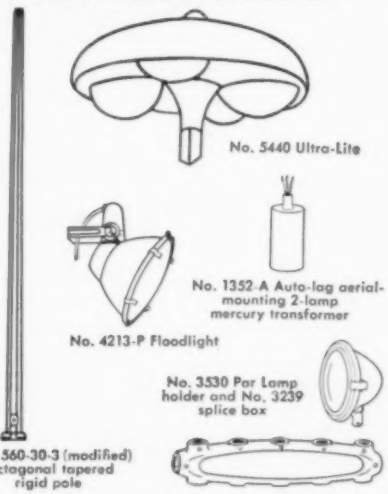
The Problem: To provide outstanding lighting for this unique super service station, so that it could compete favorably for night business with locations on the other three corners of this busy Chicago area intersection.

The Answer: Revere Ultra-Lites for service area lighting, with Revere floodlights for perimeter lighting.

Total service area of "Auto World" installation measures slightly under 10,000 square feet. Service area illumination is approximately 25 foot candles, average, with a ratio of about 2 to 1 overall. This level of illumination with its striking effect, was achieved with 9 Revere Ultra-Lites mounted on 24 foot standards. Perimeter lighting called for 4 standards, each standard mounting 3 Revere "4200" series floodlights. Clusters of 4 par lamp holders were mounted midway on three standards, beamed at the front of the building to emphasize functional detail.

The unusual degree of light uniformity at grade level is due to the pattern thrown by Ultra-Lites. Each Ultra-Lite luminaire is equipped with four 400-watt E-H1 mercury lamps. The controlled beam from the street lighting refractor produces a good shielding angle with high utilization and a square pattern of light.

Revere components used in "Auto World" installation


No. 5440 Ultra-Lite
No. 1352-A Auto-lag aerial-mounting 2-lamp mercury transformer
No. 4213-P Floodlight
No. 3530 Par Lamp holder and No. 3239 splice box
No. 560-30-3 (modified) Octagonal tapered rigid pole

This installation was planned by Revere lighting engineers, selecting the most appropriate lighting combination from Revere's wide group of outdoor lighting fixtures and fittings. No matter what the lighting problem — if it's outdoors, Revere has the equipment, or can engineer it, to provide your best lighting answer.

Revere ELECTRIC MFG. CO.®

Write for catalog covering Revere's complete line of matched outdoor lighting equipment

Revere Electric Mfg. Co., 6009 Broadway, Chicago 40, Ill., UPtown 8-7100

Available in Canada thru Curtis Lighting, Ltd., Leaside, Toronto, Ontario

OUTDOOR LIGHTING: Industrial • Commercial • Service Stations • Streets • Sports • Airports • Shopping Centers

Integrated ceilings were used to revitalize the interiors. Wm. G. Merchant, Architect; Smith and Garthorne, Consulting Electrical Engineers; Chas. B. Farrow, Inc., Electrical Contractor. All in San Francisco.

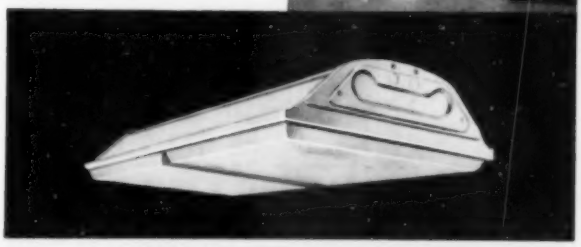
HOW TO MAKE NEW BUILDINGS FROM OLD...

Pacific Gas & Electric Company did it with integrated ceilings featuring 3700 ALL-BRITE MODU/LITERS

EASY!

Formula for a magic transformation: take an old building with high ceilings, suspend new ceilings on T-bar frames with all heat and air ducts **above**, rest All-Brite Modu/Liters on same T-bars, remodel below. Voila! — a new interior, bathed in 100 foot candles of evenly distributed fluorescent light. Wm. G. Merchant, with Smith and Garthorne, did it for P. G. & E. in San Francisco . . . you can do it, too! Ask us for the full story.

All-Brite
LIGHT OF THE WEST

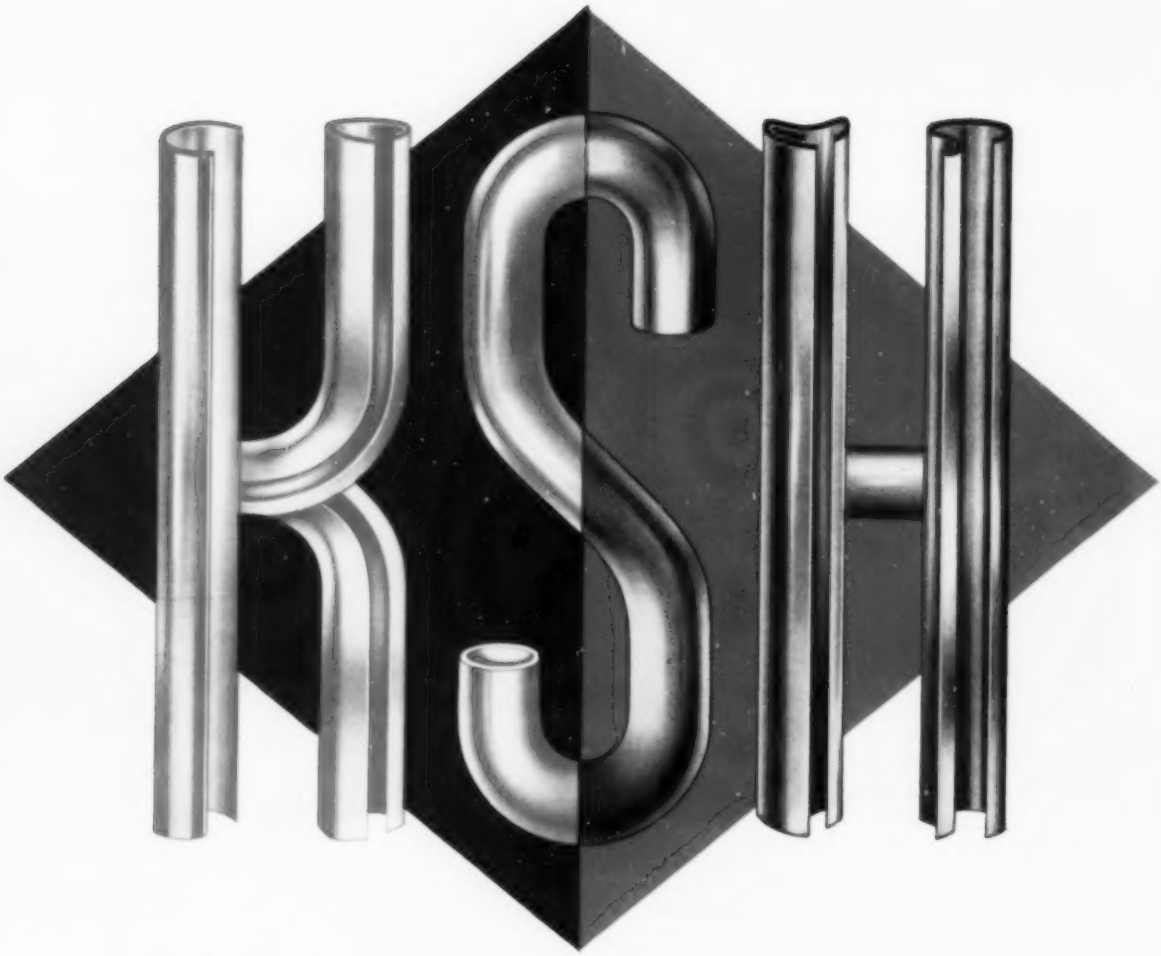


All-Brite Modu/Liter is made in 2 x 4 foot modules, for 2, 3 or 4 rapid start lamps. Fixtures rest on T-bars supporting new ceiling. All ductwork is above.

FLUORESCENT FIXTURES OF CALIFORNIA

352 SHAW ROAD
SOUTH SAN FRANCISCO, CALIF.

PLANTS ALSO IN LOS ANGELES; PORTLAND, OREGON; AND VANCOUVER, B. C., CANADA



highest quality plastic extrusions

increase the sales appeal of your products.

They practically pay for themselves through increased quality and improved appearance. You save time and trouble in processing and assembly without cost increase.

K S H Extrusions are consistently uniform in color, size and shape. They pass your most rigid standards.

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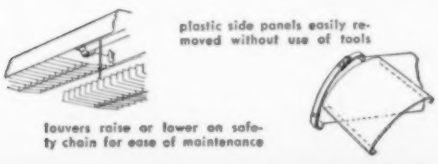
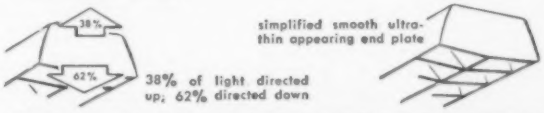
Pacesetter in the Lighting Industry

Here is America's newest, most feature-packed direct-indirect luminaire. The Daystar's long smooth-flowing appearance, its simplified ultra-thin design, plus its efficient output of high levels of quality illumination make it ideal for use in today's modern classrooms, offices, stores and other commercial interiors.

The Daystar is available in 48 and 96 inch lengths with 35° crosswise and 25° or 45° lengthwise shielding. The side panels are of steel baked white enamel or plastic. The steel baked white enamel louvers have a special snap-in catch and raise or lower on a safety chain for ease of relamping and maintenance. For complete data of all the new Daystar features that make other direct-indirect units obsolete, mail the coupon today!





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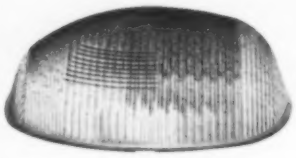
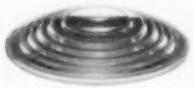


Street light refractor



Railroad signal lens

High intensity runway marker

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From the giant steel fingers of radio and television towers come wave lengths that give us information, entertainment and companionship. Towers in excess of 150 feet height are topped with a flashing beacon and the structure is outlined with steady red warning lights. Corning heat-resisting glassware that withstands the elements, transmits true color and closely controlled beam pattern, keeps aircraft at a safe distance.

Corning produces many special items which make travel safe, be it by land, sea or air.

CORNING GLASS WORKS
CORNING, NEW YORK

Corning means research in Glass

Modern Lighting *by* PERFECLITE

makes learning easier on young eyes . . . increases teaching efficiency

For schools, where visual comfort is such a vital factor in scholastic achievement and physical well being, more and more architects and engineers specify Perfeclite. Case in point —the recently renovated and enlarged Peters Township, Pa. Junior-Senior High School, where one million dollars was spent in repairs and new building. Perfeclite fixtures light the way in classrooms and corridors—help create an ideal environment for students and teachers alike.

In schools, offices, factories—in fact, wherever you have a commercial or institutional lighting problem – there's a low cost, easy-to-install Perfeclite fixture ideally suited to your requirements.

Write today for further information.

INSTALLATION: Peters Township, Pa. Junior-Senior High School.

AREA SHOWN: Typical classroom and corridor.

ARCHITECTS: Beall & Parkins, Washington, Pa.

ELECTRICAL CONTRACTOR: Edward Regula, Belle Vernon, Pa.

FIXTURES: Perfeclite F-387-AT recessed asymmetric drop prismatic lens 200 watt corridor fixtures. Perfeclite P-303 plastic three ring shadowless, non-glare translucent 500 watt ceiling fixtures.

CEILING HEIGHT: 8'6" in corridor —11'10" in classroom.

FIXTURE SPACING: 9'6" in classroom—12'0" in corridor.

INTENSITY: 46 ft.-candles average throughout classroom at desk level. 20 ft.-candles average throughout corridor at locker level.

THE PERFECLITE COMPANY

1457 EAST 40th STREET • CLEVELAND 3, OHIO

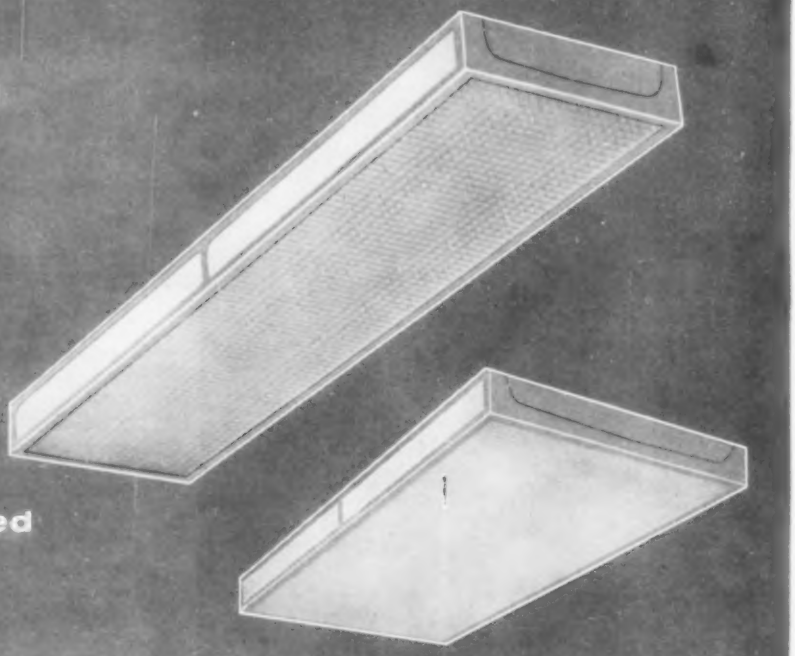
PERFECLITE PRODUCTS — THE MARK OF LIGHTING SERVICE

Fixtures are Underwriters Laboratories, Inc. approved

Introducing GARCY Lighting's

60th ANNIVERSARY SERIES

New Surface-Mounted Fixtures



- 2 or 4 lamp units, only 3½" deep
- Hinged one-piece enclosures
- Regular or translucent sides
- For 48" rapid start lamps

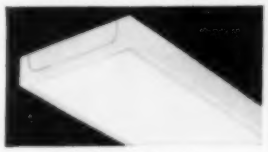
Especially suitable for modern low ceilings, the 60th Anniversary Series embodies simplicity in design, glare-free visual comfort and efficient light utilization. This versatile series offers unique advantages to cost-conscious contractors.

ONLY TWO BASIC PARTS TO INSTALL

1. Compact Chassis
2. One-Piece Enclosure

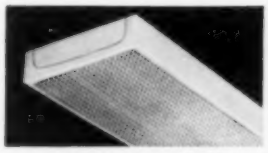
The lightweight chassis is easy to handle. Hinged enclosure is furnished ready for installation . . . no small parts to assemble.

Your Choice of these Distinctive Treatments

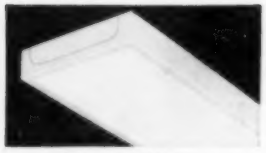


ALBA-LITE GLASS

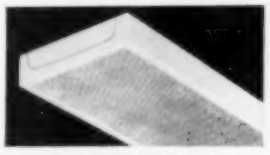
ONE-PIECE PLASTIC LOUVER



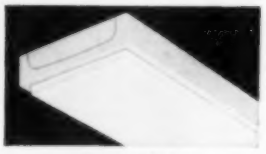
EXTRULITE CLEAR PLASTIC



FLAT PLEXIGLAS PANEL



LOW BRIGHTNESS LENS



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(Continued from page 22A)

Copies may be obtained in minimum lots of 1000 for $.02 per copy. Orders should be sent to Myron D. Miller, Secretary, Wire and Cable Section, NEMA, 155 East 44th Street, New York 17, N. Y.

The 1958 edition of the **Price List and Index of American Standards** is now in print. This booklet, which lists over 1700 American Standards is available from ASA, 70 East 45th Street, New York 17, N. Y.

NEW MEMBERS

At the meeting of the I.E.S. Council on February 13, the following were elected to membership. Names marked * are transfers from Associate Member Grade. Names marked ** are transfers from Student Member Grade.

ALABAMA SECTION

Associate Member:
Clark, J. H., Alabama Power Co., Birmingham, Ala.

ARIZONA SECTION

Member:
Dragoo, J. F., P. O. Box 231, Sierra Vista, Ariz.

Associate Members:
Clayton, F. S., Phoenix Electric Supply, Phoenix, Ariz.
Jones, E. S., Jones Electric Co., Phoenix, Ariz.
Stead, Harold, Arizona Highway Dept., Phoenix, Ariz.
Struthers, W. D., Arizona Lighting Supply Co., Phoenix, Ariz.

ARKANSAS CHAPTER

Associate Member:
Smith, J. E., Garybar Electric Co., Little Rock, Ark.

ARK-LA-TEX CHAPTER

Associate Members:
Bennett, J. J., Carl Pons Electrical Co., Shreveport, La.
Roberson, J. L., Graybar Electric Co. Inc., Shreveport, La.

BLUENOSE CHAPTER

Associate Member:
McNeil, P. A., 166 Great George St., Box 513, Charlottetown, P. E. I.

BRITISH COLUMBIA SECTION

Associate Members:
Eadie, J. A., Brettell Electric Ltd., Vancouver, B. C.
Martin, B. J., Canadian General Electric Co., Vancouver, B. C.

CAPITAL SECTION

Member:
*Brady, F. B., Mills Petticord & Mills, Washington, D. C.

Associate Member:
Ruth, B. W., General Electric Supply Co., Washington, D. C.

CENTRAL NEW YORK SECTION

Member:
*Way, J. E., N. Y. State Electric & Gas Corp., Johnson City, N. Y.

CHICAGO SECTION

Members:
Capps, J. S., Underwriters' Laboratories, Inc., Chicago, Ill.

(Continued on page 42A)

applications unlimited!

Margaret R. Read, M.D.
Physician's Suite — waiting room, X-ray room, office and examining rooms.
Architect: John T. Kelly, Cleveland
Equipment by: The Wakefield Company
Using FLAT Soundsheet
3' x 3' squares
framed under tension
Tufts University, Bray
Mechanical Engineering Lab
Architects: William A. Pollack, NEGEA SERVICE CORP., Cambridge, Mass.
Equipment by: Smithcraft Lighting
Using CORRUGATED Soundsheet
on 2 ft. centers.
TWA Reservations Office, Boston.
Architect: Thomas F. McDonough, Boston
Equipment by: Luminous Ceilings, Inc. Office, Boston
Using CORRUGATED Soundsheet
in 3 ft. modules

CONTREX

SOUNDSHEET

TRANSLUCENT ACOUSTICAL ELEMENT — ONLY Soundsheet successfully combines acoustical and light diffusing properties! Today's important new architectural tool, Contrex Soundsheet can be used effectively with most wall-to-wall or area lighting systems for remodelling or new construction. Available from coast to coast through the nation's leading manufacturers of lighting and acoustical equipment, Soundsheet can also replace or supplement other acoustical or lighting media now installed.

Because of Soundsheet's unique versatility, many applications are being developed, such as functional sound absorbers, back-lighted wall treatments, duct-lining to reduce sound . . . and space dividers. Also it can be produced to equipment manufacturer's specifications in patterns and COLOR, translucent or opaque.

- *Easy to install*
- *Balanced sound absorption*
- *Softly diffused lighting free of shadows and reflections*
- *Washable*
- *Harmonizes perfectly with any of today's architectural interior concepts*
- *Available in FLAT or CORRUGATED sheets*
- *U.L. listed*

WRITE today for more information about the many advantages — the many applications for Soundsheet and how they can benefit you.

"SOUNDSHEET . . . *for new ideas in sound and sight*"

CONTREX

CONTREX COMPANY
Chelsea 50, Mass.

Developed for Contrex by Bolt Beranek and Newman Inc.

MAIL TO:
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CHELSEA 50, MASS.

☐ Please send me literature and samples of SOUNDSHEET.
☐ Please send me a list of the authorized manufacturers who include Soundsheet in their lighting equipment.
I'm interested in Soundsheet
☐ for use as acoustical ceiling.
☐ for use in new application.

Name _____
Company _____
Address _____
City _____ State _____

IE-3

AVAILABLE FROM COAST TO COAST THROUGH AUTHORIZED MANUFACTURERS OF LIGHTING AND ACOUSTICAL PRODUCTS.

bright for life

thanks to **CHAMPION LIGHTMANSHIP**

MILLIONS OF LAMPS A YEAR . . .

ONE PLANT standard of quality control

With all manufacturing concentrated in the big, modern plant shown above, every Champion lamp is subjected to a single, high standard of quality control.

Uniform control like this is one more example of how Champion applies Lightmanship to make sure you always get all the light you pay for in Champion lamps.

CHAMPION LAMP WORKS
Lynn, Massachusetts
A division of Consolidated Electric Lamp Co.

CHAMPION Lamps
Incandescent Fluorescent
Your best buy in lamps

(Continued from page 41A)

Schlehuber, R. C., Beling Engineering Consultants, Rockford, Ill.

Associate Member:

Bridges O. D., Verd-A-Ray Corp., Elkhart, Ind.

CHINOOK CHAPTER

Member:

Steadman, A. E. W., Southern Alberta Jubilee Auditorium, Calgary, Alta.

CLEVELAND SECTION

Member:

*Howard, G. T., General Electric Co., Cleveland, Ohio.

Associate Member:

Klein, M. D., General Electric Co., Cleveland, Ohio.

CONNECTICUT SECTION

Member:

Kerr, H. A., Connecticut State Highway Dept., Hartford, Conn.

Associate Member:

Teraila, B. J., Hartford Electric Light Co., Hartford, Conn.

EASTERN NEW YORK SECTION

Associate Member:

Wilcox, H. R., Lustra Corp. of America, Brooklyn, N. Y.

EASTERN PENNSYLVANIA SECTION

Associate Member:

Steigerwalt, C. H., Jr., Sylvania Electric Products Inc., Philadelphia, Pa.

EDMONTON CHAPTER

Associate Member:

Lutz, Ray, Hammond Electric Co., Edmonton, Alta.

FLORIDA SECTION

Member:

Jaffer, R. P., Britt-Curley Associates, Tampa, Fla.

Associate Member:

Kenyon, W. E., 3119 Ashton Road, Sarasota, Fla.

FOREIGN NON-SECTION

Associate Member:

Burke, H. B., Dept. of Electricity, Government of Kuwait, Kuwait, Persian Gulf.

FOREST CITY (LONDON) CHAPTER

Associate Members:

Thomas, J. L., J. V. McDonnell Electric Co., Ltd., London, Ont.

Waugh, J. E., S. H. Myles, London, Ont.

GOLDEN GATE SECTION

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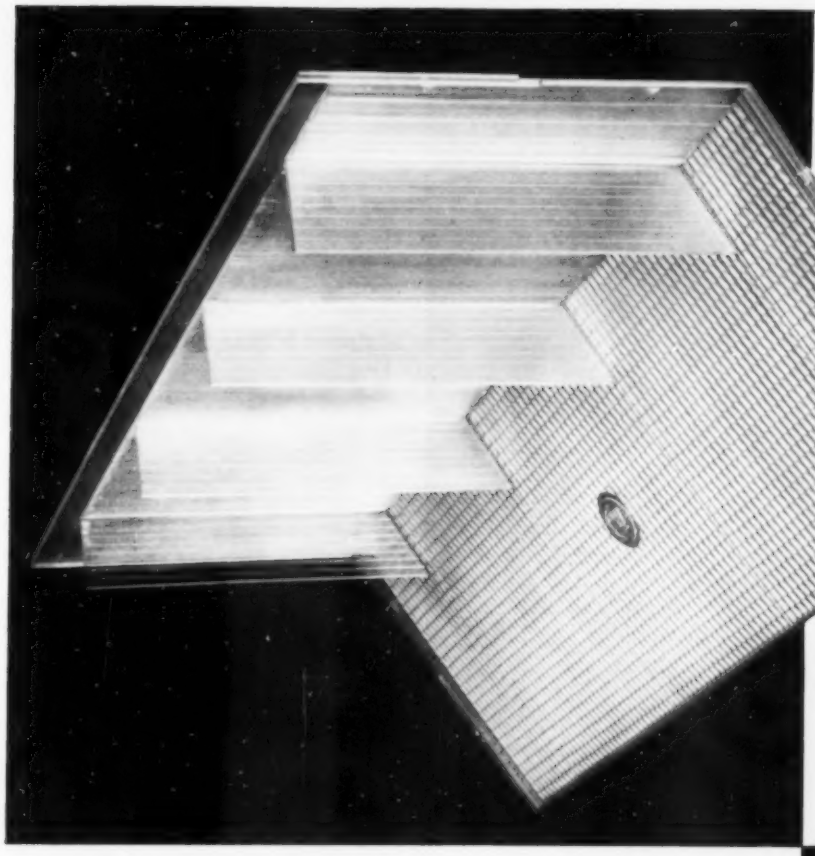

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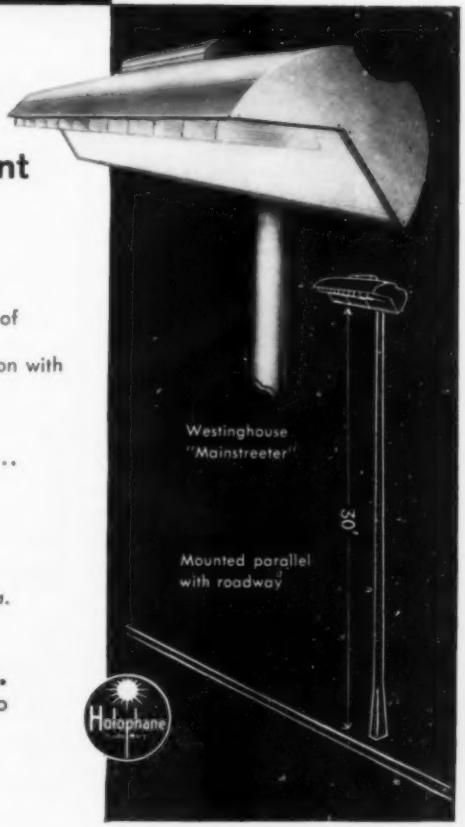

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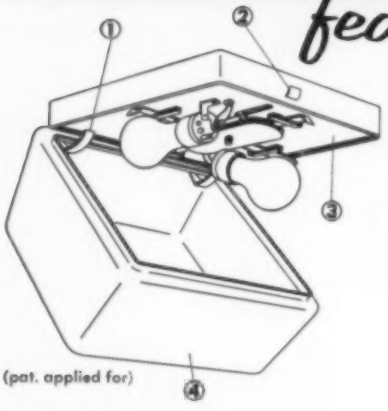

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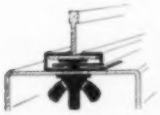

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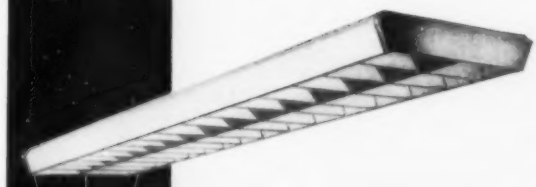

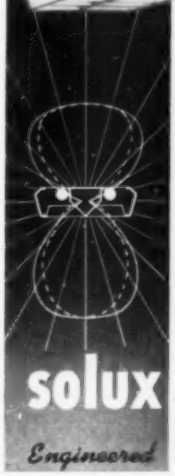

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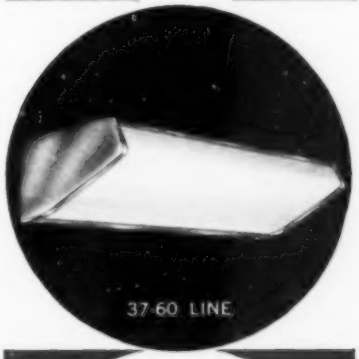

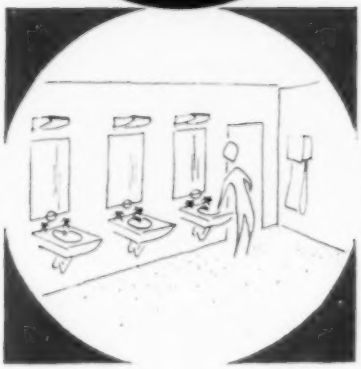

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New Equipment Data

(Continued from page 24A)

(20) LOW BRIGHTNESS LENS called Directo-Lens is shown in four-page two-color brochure which together with a series of six photometric data pages gives details on complete new line of glass lenses for use by fixture manufactures. Phoenix Glass Co., Monaca, Pa.

(21) CONDENSED FLUORESCENT CATALOG. New eight-page catalog is for handy reference and gives highlights of company's complete line of commercial, industrial units, recessed troffers and ceiling systems, with descriptions and illumination data. Smitheraft Lighting Division, Chelsea, Mass.

(22) SUBSTATION LIGHTING UNIT, newly-designed, is described in data sheet 04250 which pictures and gives outstanding characteristics and photometric data on luminaire for outdoor substation lighting. Complete details as to construction and materials are provided. Holophane Co. Inc., New York, N. Y.

(23) STORE LIGHTING. Catalog 7 "Lighting for Selling" shows wide variety of company's line of incandescent and fluorescent luminaires for mercantile installation, including directors and bowls, spheres, cornice and perimeter lighting, as well as fluorescent strips and showcase reflectors. Peerless Electric Co., San Francisco, Calif.

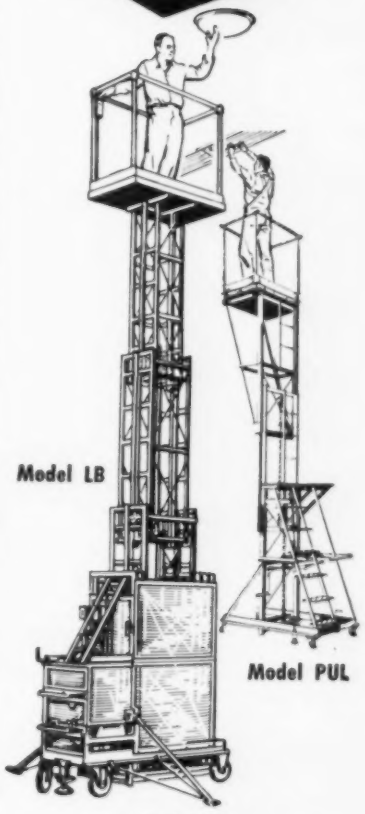
(24) FLOODLIGHTING. Six new catalog pages cover new Series 4000, 300- to 1500-watt floodlights for sports and industrial applications; new hinged floodlight poles and standards; and new fluorescent area floodlights for service stations, etc. Steber Mfg. Co., Broadview, Ill.

(25) RECESSED TROFFERS of lay-in type called Versaline-Grid are described in Bulletin VG-857. Units were designed especially for use in exposed-T furring in stores, offices, schools and public buildings, and are said to assure 100 fixture types from three basic sizes; available with wide variety of diffusers. Miller Co., Meriden, Conn.

(26) FLUORESCENT HIGH-BAY FIXTURES. Four-page, two-color data folder features new industrial luminaire utilizing Power-Groove lamps; pictures recent installation with illumination data and gives fixture specifications and photometric data. Fluorescent Fixtures of California, South San Francisco, Calif.

(27) INCANDESCENT LUMINAIRES. Catalogs 4-1 and 4-2 describe company's new Inca-Light line of surface mounted and pendent enclosed luminaires available in a wide variety of glass shapes for many types of installation; folders furnish construction and illumination data. J. A. Wilsen Lighting & Display Inc., Erie, Pa.

90% of overhead servicing can be done faster and safer with these ECONOMY Hi-Reach Telescopers!



Model LB
HI-Reach Telescopers
Four heights 20 ft. to 35 ft.
Standard Models from $1510.00 up.

Model PUL
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No. 1 — Lift 10' 9" **$370.00**
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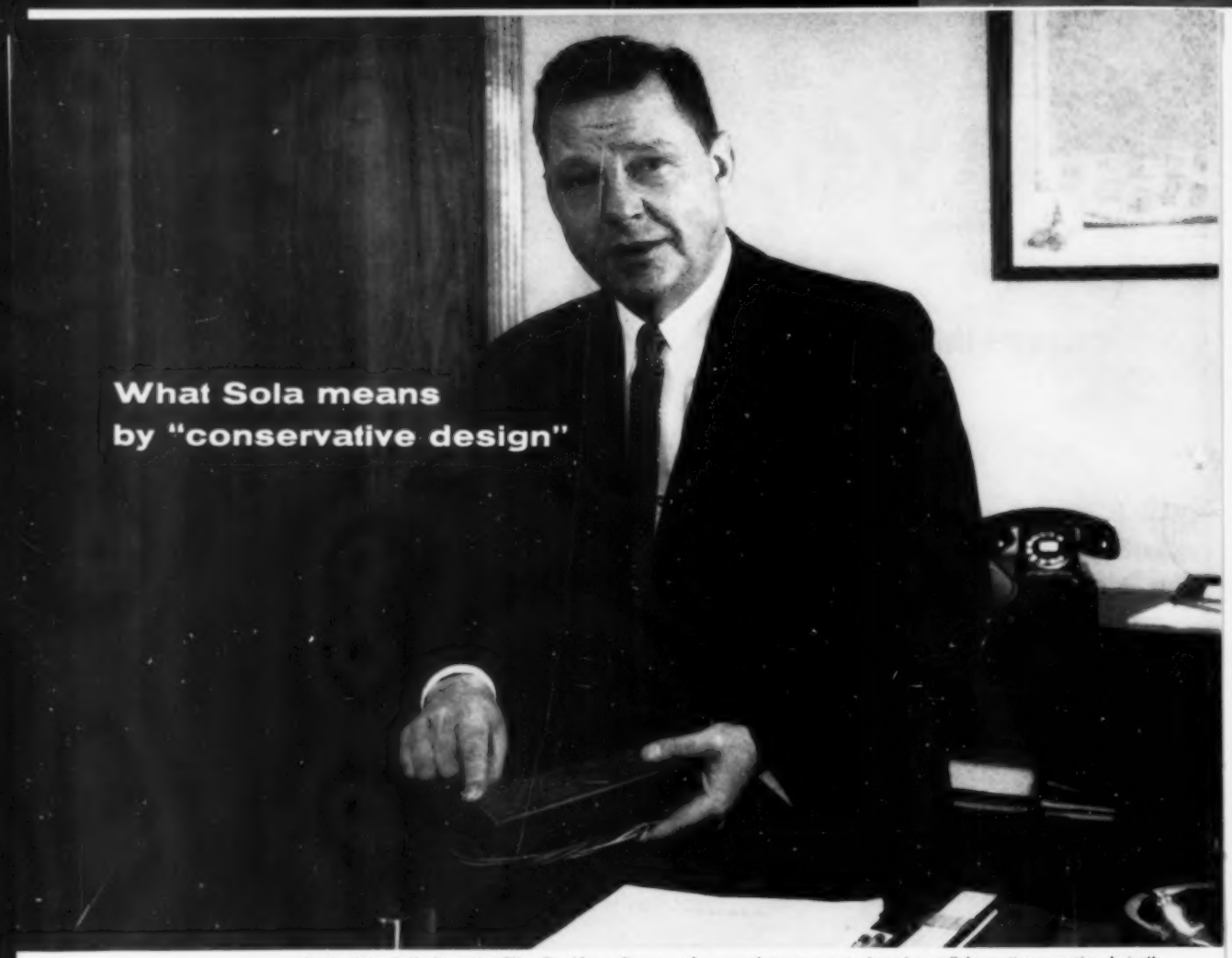
ECONOMY ENGINEERING



L. C. Marschall, Executive Vice President, discusses the general management viewpoint at Sola on "conservative design"

"Anything less than CBM ballast standards is unacceptable at Sola"

Is a product that just meets the *minimum* standards set by inter-industry agreement acceptable? We at Sola Electric Co. believe not. The manufacturers of fluorescent lamps and fluorescent ballasts have jointly set minimum standards for ballasts. *Any* ballast meeting these minimums can be so certified by the Certified Ballast Manufacturers.

At Sola, however, we go even further. We design an adequate margin of performance into each unit over and above the CBM minimum specification. Extra iron, copper, and reserve tolerance in each component —the conservative design of Sola ballasts — assures *quality exceeding* the CBM standard.

It is our firm management policy that, "Sola ballasts are designed and built to surpass CBM standards."

Every Sola general lighting ballast, for which a CBM specification exists, is a certified CBM ballast. We refuse to market anything less.

Write for "An Analysis of Fluorescent Lighting Systems Costs"

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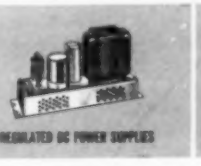
SOLA

CONSTANT VOLTAGE TRANSFORMERS


REGULATED DC POWER SUPPLIES

MERCURY LAMP TRANSFORMERS

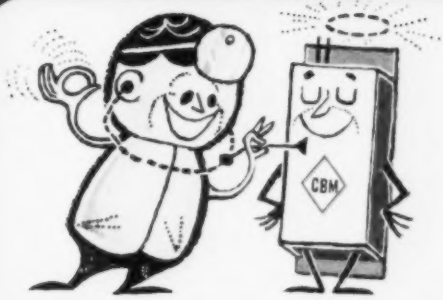
FLUORESCENT LAMP BALLASTS

LOWER LIGHTING COSTS

with fluorescent fixtures using

CERTIFIED CBM BALLASTS

UP TO 2500 HOURS MORE LAMP LIFE in fixtures using Certified CBM Ballasts. And rated light output, too. That's what tests by fluorescent lamp makers show.



TROUBLE-FREE SERVICE . . . for Certified CBM Ballasts provide assured ballast life . . . quiet operation . . . minimize replacements and repairs.

MADE TO EXACTING SPECIFICATIONS for performance by 8 leading ballast manufacturers, CBM Ballasts are checked and certified by ETL. And they're UL listed, also.

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CERTIFIED BALLAST MANUFACTURERS

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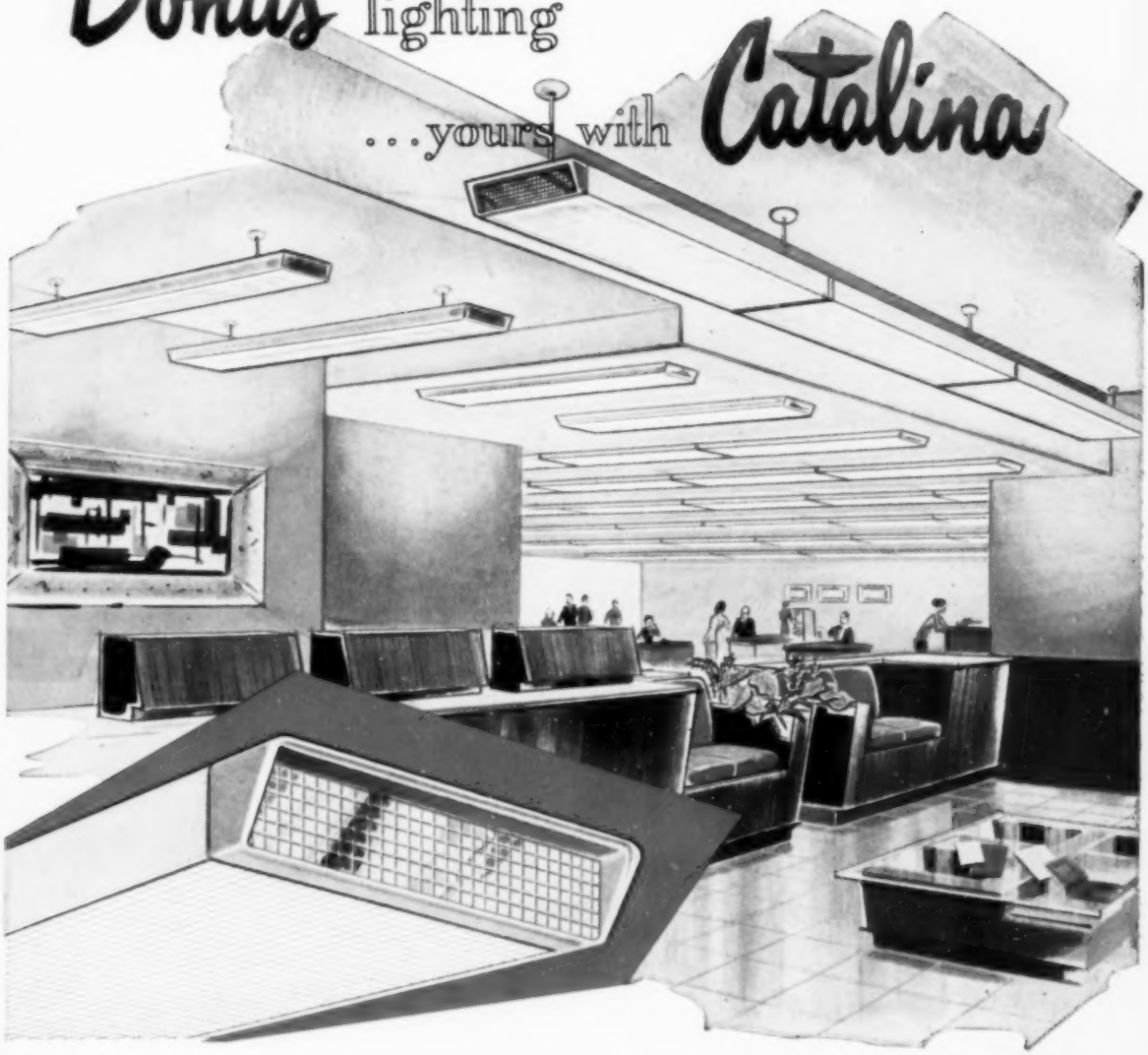
Participation in CBM is open to any manufacturer who wishes to qualify

CBM-6-CU

Bonus lighting ...yours with Catalina



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